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5002 AND 5003
DIGITAL TEST INSTRUMENTS
Models 26.220 and 26.219

VOLUME I

EAI

ELECTRONIC ASSOCIATES INC. ■ LONG BRANCH, NEW JERSEY

EAI ELECTRONIC ASSOCIATES, INC. ■ LONG BRANCH, NEW JERSEY

5002 AND 5003
DIGITAL TEST INSTRUMENTS
Models 26.220 and 26.219

VOLUME I

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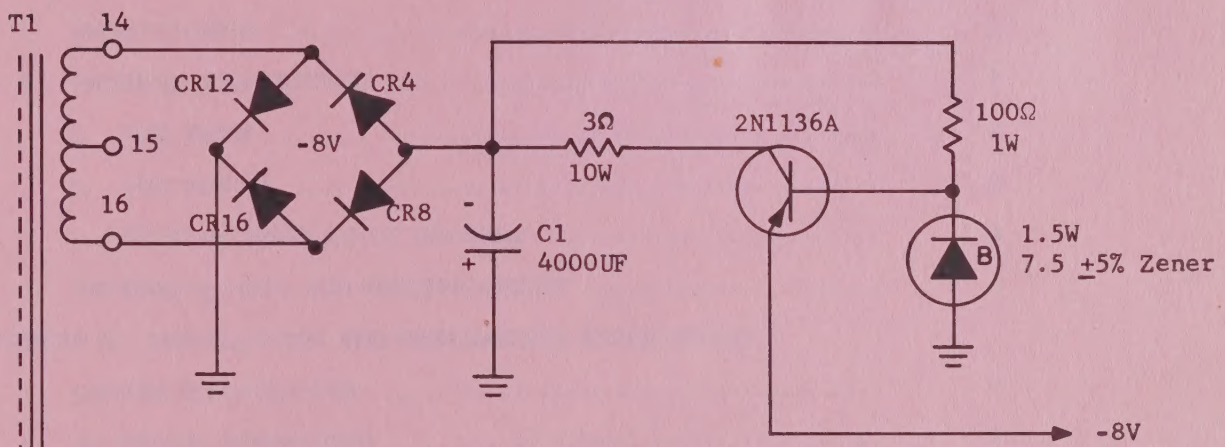
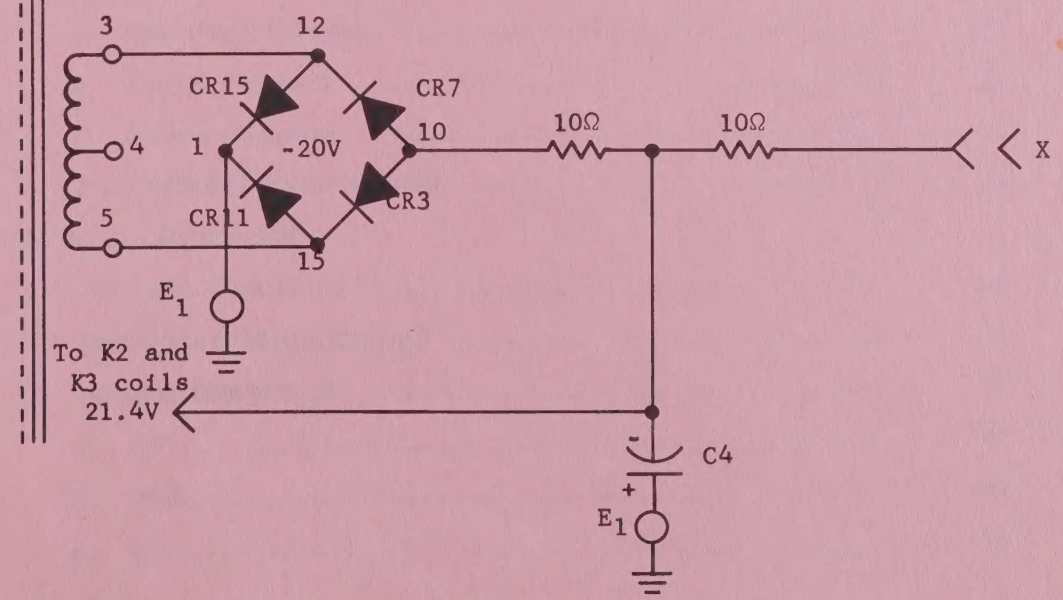
NOTICE

In some models of the 5003 TDVOM, a regulator circuit has been added to the -8V power supply. The output of the -20V rectifier has has also been modified. See Drawing D026 158 0S, Sheet 4 and Figure 1 below.



-8V Supply (Modified)



-20V Supply Modified

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Figure 1. 5002 Series Digital AC-DC Voltmeter, Three-Quarter Front View

Figure 2. 5003 Series Digital AC-DC Volt-Ohmmeter, Three-Quarter Front View

CHAPTER I

GENERAL DESCRIPTION

1. INTRODUCTION

The EAI (Electronic Associates, Inc.) 5002 and 5003 Series Digital Test Instruments, shown in Figures 1 and 2, are fast and precise instruments designed for field or laboratory use. The 5002 Series consists of a 5002A Transistorized Digital Voltmeter (TDVM) and a 5002B AC-DC Converter. This combination provides an automatic-ranging AC/DC digital voltmeter capable of measuring up to 1000 volts AC or DC plus 20% over-range. The 5003 Series consists of a 5003A Transistorized Digital Volt-Ohmmeter (TDVOM) and a 5003B AC-DC Converter. This unit contains all the features of the 5002, plus four ohm ranges.

Because of the similarity in these units, this manual describes both the 5002 Transistorized Digital AC-DC Voltmeter, and the 5003 Transistorized Digital Multimeter. The manual consists of two volumes; Volume I contains the text and replaceable parts lists, and Volume II contains the necessary drawings. Unless otherwise specified, all information given applies to both the 5002 and 5003 Series.

2. PHYSICAL DESCRIPTION

These units are supplied with a heavy-duty dust cover for bench use, or with standard 19 inch RETMA panels for rack mounting. The units are completely self-contained, and employ conservatively rated, solid-state components throughout. Overall dimensions for the units are listed below:

	For Rack Mounting	With Dust Cover
Height	8-3/4 inches	9-1/2 inches
Depth	16 inches	17-1/4 inches
Width	19 inches	19-1/4 inches

Each 5002 and 5003 consists of two chassis; an AC-DC Converter (5002B or 5003B), and a TDVM (5002A) or a TDVOM (5003A). Each chassis is described separately in the following paragraphs.

a. 5002A TDVM

The components in the 5002A TDVM (with the exception of some networks and power supply components) are mounted on etched-circuit cards which plug into chassis-mounted connectors. Table I lists the various plug-in cards, the circuit designation, and the chassis-mounted connector designation. The physical location of each card is shown in Figures 3 and 4.

In addition to the plug-in cards, certain other components are in the form of network assemblies mounted on the TDVM. These units are listed in Table II.

Physical dimensions of the TDVM chassis are:

Height ..... 5-1/4 inches

Depth ..... 16 inches

Width ..... 19 inches

TABLE I. 5002A Plug-In Cards

Card Nomenclature	Model Number	Quantity Required	Circuit And Chassis Connector Designation
Dual DC Amplifier	6.463	1	AR1-J1
Reference Amplifier	6.464	1	AR2-J1
Comparator and Diode Gate	26.096-3	1	A1-J1
Binary Coded Decade Counter	44.139-5	1	A2-J1 (1000's)
Binary Coded Decade Counter	44.139-1	3	A3-J1 (100's) A4-J1 (10's) A5-J1 (1's)
Programmer	44.170-3	1	A6-J1
Readout Storage Decade	51.010-1	3	A7-J1 (1's) A8-J1 (10's) A9-J1 (100's)
Readout Storage Decade	51.080-1	1	A10-J1 (1000's)
Auto Range Switching	14.156	1	A11-J1
Summing Resistor Network	26.116	1	NW2-J1
Miscellaneous Network Card	12.687	1	NW7-J1
Power Supply Regulator	43.094-1	1	VR1-J1

TABLE II. 5002A Chassis Mounted Networks

Network Nomenclature	Model No.	Quantity	Chassis Designation
Rectifier Network	12.675	1	NW8
Reference Amplifier Network	12.722	1	NW6
Input Resistor Network	12.725	1	NW1

b. 5003A TDVOM

The 5003A TDVOM consists of a 5002A TDVM modified to incorporate four ohm scales. The 5003A is physically similar to the 5002A with the following exceptions:

(1) Input Resistor Network 12.879 replaces Network 12.725.

(2) Miscellaneous Network 12.687-1 replaces Miscellaneous Network 12.687.

(3) Two additional range relays are used, K4 and K5.

(4) The RANGE switch is modified to provide the four ohm ranges.

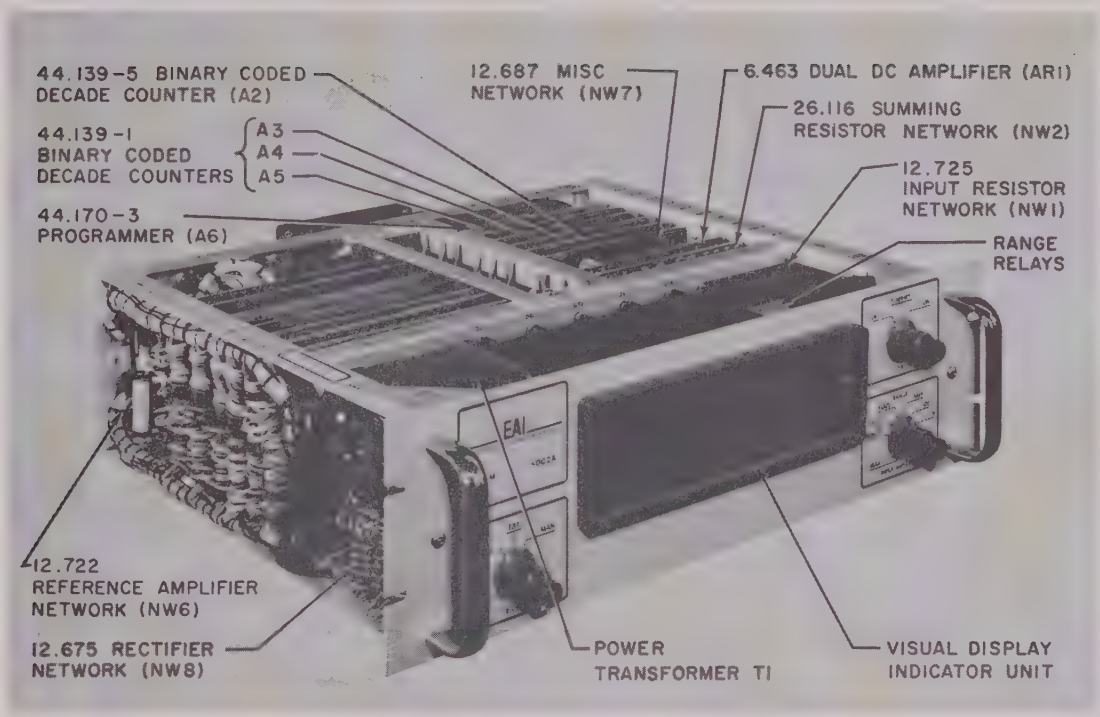


Figure 3. 5002A Chassis, Component Location (Front View)

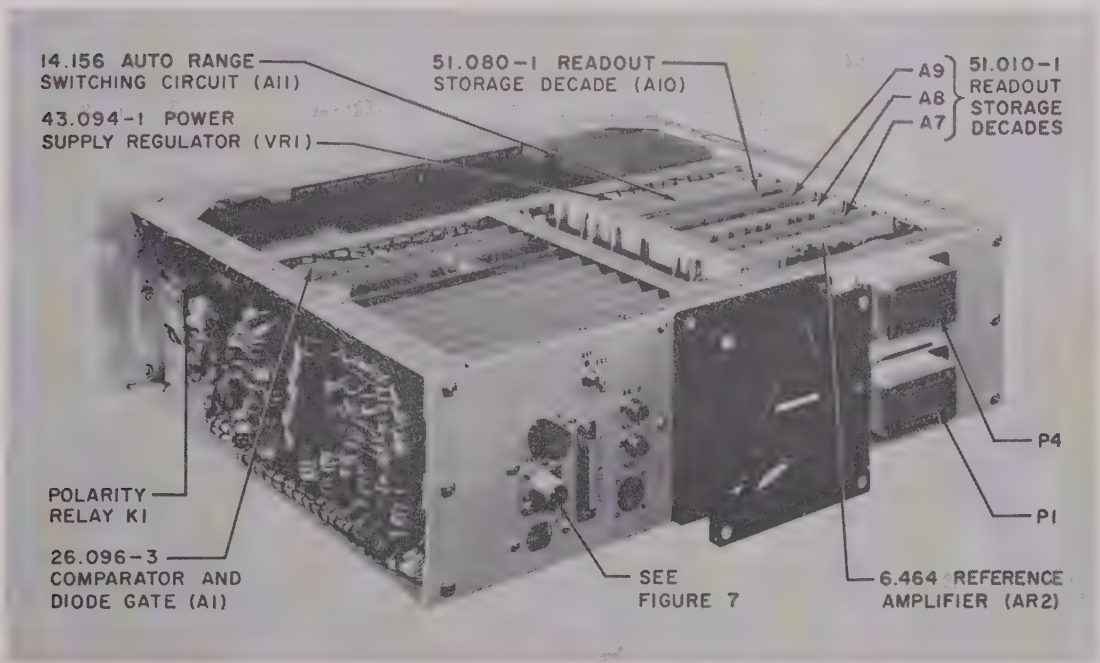


Figure 4. 5002A Chassis, Component Location (Rear View)

c. 5002B and 5003B AC-DC Converter

The components in the AC-DC Converter (with the exception of one network and some power supply components) are mounted on etched circuit boards which plug into chassis-mounted connectors. Table III lists the various plug-in cards, the circuit designations, and the chassis-mounted connector designation. The physical location of each card is shown in Figures 5 and 6. The chassis-mounted network is the Command Relay Drive Network, Model 11.159.

TABLE III. AC-DC Converter Plug-In Cards

Card Nomenclature	Model Number	Quantity Required	Circuit And Chassis Connector Designation
Dual DC Amplifier	6.617	1	AR1-J1
Dual DC Amplifier	6.334	1	AR2-J1
Amplifier Network	12.889-1	1	NW1-J1
Amplifier Network	12.890	1	NW2-J1
Resistor Network	12.884	1	NW3-J1
Power Supply Regulator	43.031-2	1	VR1-J1

Physical dimensions of the AC-DC Converter chassis are:

Height ..... 3-1/2 inches

Depth ..... 16 inches

Width ..... 19 inches

3. TECHNICAL DATA AND SPECIFICATIONS

a. Input Ranges (Both the 5002 and 5003 can accept 20% overloads on all ranges.)

(1) AC ..... 0 to 1 volt RMS

0 to 10 volts RMS

0 to 100 volts RMS

0 to 1000 volts RMS

(2) DC ..... 0 to ±1 volt

0 to ±10 volts

0 to ±100 volts

0 to ±1000 volts

(3) Ohms (5003 only)..... 0 to 1 Kilohm

0 to 10 Kilohms

0 to 100 Kilohms

0 to 1000 Kilohms

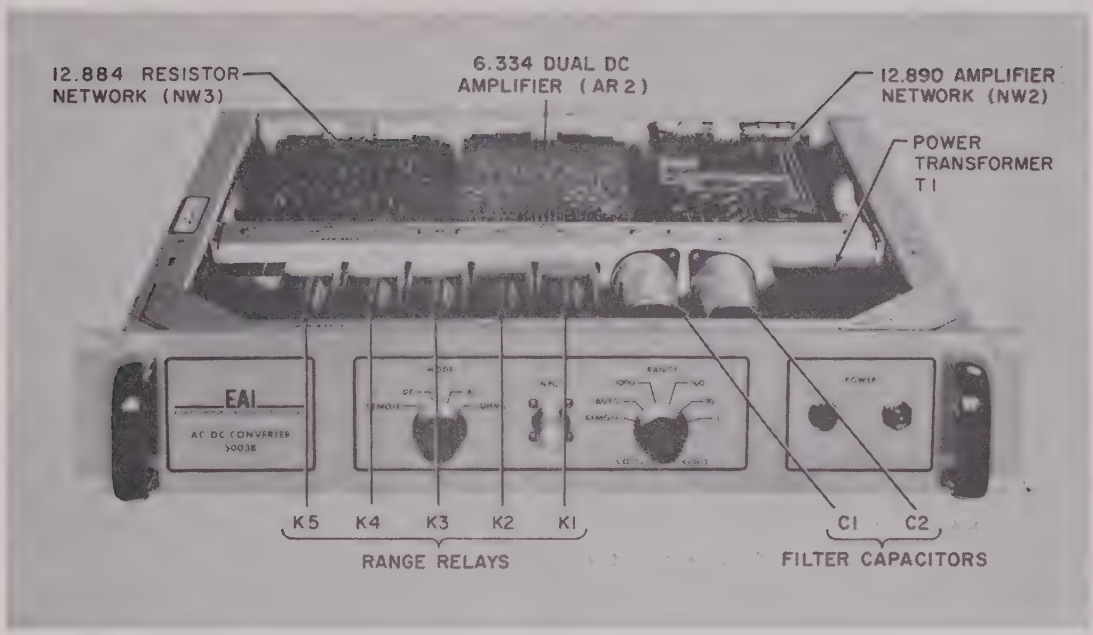


Figure 5. AC-DC Converter Chassis, Component Location (Front View)

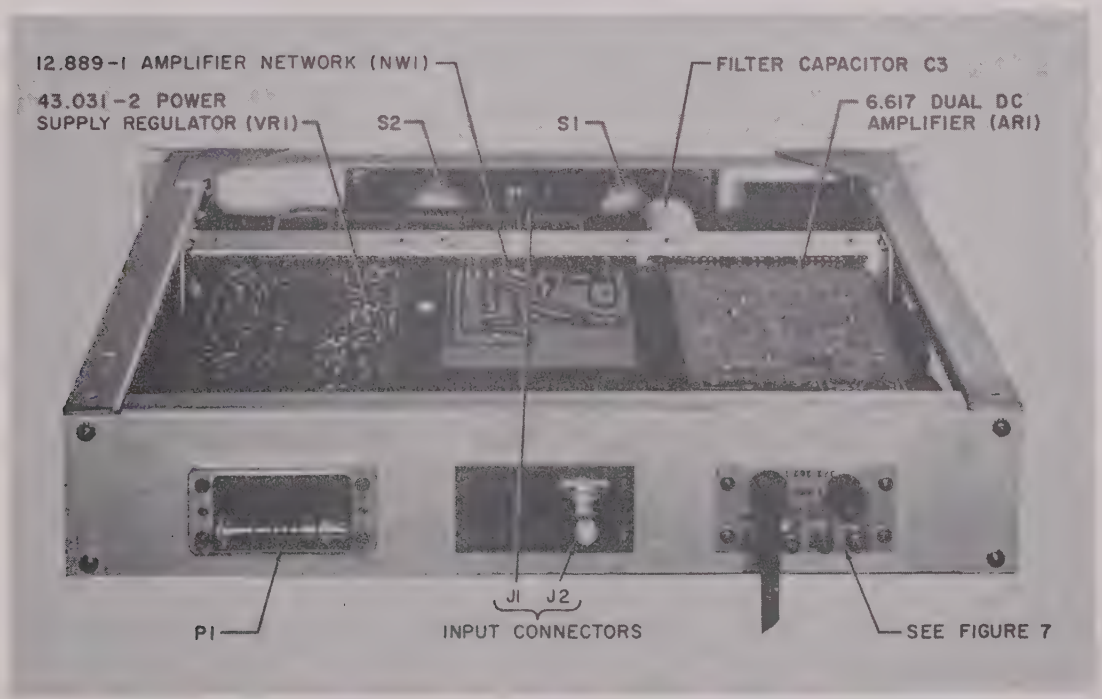


Figure 6. AC-DC Converter Chassis, Component Location (Rear View)

b. Input Impedance

(1) AC ..... 1 Megohm resistive on all ranges

(2) DC ..... Dependent on range

RANGE	IMPEDANCE (Megohms)
1 volt	250 Minimum*
10 volts	500 Minimum*
100 volts	10
1000 volts	10

c. Readout Time

(1) DC ..... 0.6 seconds with automatic range and polarity change.

0.30 seconds with automatic range change, no polarity change.

0.01 seconds with no change in range or polarity.

(2) AC ..... 0.75 seconds with automatic range change.
0.01 seconds with no change in range and no step amplitude change. Maximum settling time for step amplitude change is 200 milliseconds.

(3) Ohms (5003 only)..... 0.30 seconds with automatic range change.

0.01 seconds with no range change.

d. Conversion Time ..... The unknown input (DC, ohms, or DC output of the AC-DC Converter) is sampled at an *average* rate of 200 samples per second.

e. Accuracy

(1) DC ..... ±0.01% of full scale (±1 digit on all ranges.)

(2) AC ..... ±0.06% of full scale 50 CPS to 5 KC

±0.11% of full scale 5 KC to 10 KC

(3) Ohms (5003 only) ..... ±0.05% of full scale (±1 digit on all ranges.)

** A front panel switch allows the input impedance to be set to 10 Megohms for all ranges.*

f. Current Through Unknown Resistor (5003 only).... dependent on range

RANGE	UNKNOWN RESISTOR CURRENT*
1K	10 MA
10K	1 MA
100K	0.1 MA
1M	0.01 MA

g. Power Requirements ..... 117 VAC, 50/60 CPS, 96 watts (230 VAC and 400 CPS optional)

h. Rated Operating Temperature..... 55°F to 100° F

**This current is a function of the range, not the value of the unknown resistor.*

CHAPTER II

INSTALLATION AND PRELIMINARY ADJUSTMENTS

1. CHASSIS INSTALLATION

The 5002 and 5003 are completely self-contained and supplied complete with a junction box connector and a power input cable. Units for bench use are shipped in the heavy duty dust cover and require no installation other than external power and input-output connections.

Unpack the units and check that all components are in place and undamaged. To remove the chassis from the dust cover; remove the junction box connector, remove the eight screws (one in each corner of each front panel) which fasten the front panels to the dust cover, remove the 2 screws which secure the AC-DC Converter chassis to the bottom of the dust cover, and slide the two chassis out.

If the unit is to be rack-mounted, secure each chassis to the rack by running four screws (1/4-20 for an EAI rack, 10-32 for a RETMA rack) through the slotted holes in each corner of the front panels. *Secure these screws tightly.* Although the chassis are strong enough to permit mounting by the front panels only, it is recommended that supports or slide rails be installed in the rack. This will make the chassis easier to handle when removing the unit from the rack.

2. AC POWER CONNECTION

The 5002 and 5003 are equipped with standard 3-wire power cables to connect to a single-phase 115 volt source. If the power source is not wired for three-prong plugs, an adapter is required. If this arrangement is used, *the green ground lead must be connected to an earth ground.* Also, check the polarization of the AC line to be certain that the *hot* AC lead (black) is connected to the *hot* side of the source.

3. EXTERNAL CONNECTIONS

External connectors on the 5002 and 5003 provide the following connections:

a. INPUT Connectors (J1 and J2)

These coaxial connectors on the front and rear panels of the AC-DC Converter accept inputs in all modes of operation.

b. EXT REF (Optional)

This coaxial connector on the rear of the 5002A or 5003A chassis permits slaving of the TDVM or TDVOM reference circuits to an external -100 volt reference. The adjacent switch (EXT/INT) provides selection of the reference source.

TABLE IV. Test Point Connector Terminations

Connector Terminal	Circuit	Voltage or Function
1	Reference Amplifier Balance	For adjustment of Reference Amplifier Balance
2	-100V Reference	-100 VDC ±0.01%
3	+40 Power Supply Regulator	+40 DC ±1%
4	Reference Zener Check	+9.4 VDC ±10%
5	-20 Power Supply Regulator	-20 VDC ±1%
6	-110 Power Supply Regulator	-110 VDC ±1%
7	Indicator Clear	See waveform h on Figure 10
8	Amplifier-A Output	Determined by input and range setting
9	Amplifier-B Output	Determined by input and range setting
10	+2V Power Supply Regulator	+2 VDC ±10%
11	+12V Power Supply Regulator	+12 VDC ±10%
12	+20V Power Supply Regulator	+20 VDC ±1%
13	-8V Power Supply Regulator	-8 VDC ±10%
14	-12V Power Supply Regulator	-12 VDC ±10%
15	Carry In Lead	End of count pulse
16	±Ground	
17	Amplifier-B Balance	See Paragraph 2, Chapter III
18	Amplifier-A Balance	See Paragraph 2, Chapter III

c. TEST POINT Connector (P2)

This 25-pin connector on the rear of the 5002A or 5003A chassis provides certain output signals for local or remote monitoring. Table IV lists the voltages or signals available at each pin.

d. Data Output Connector (P1)

This 78-pin connector on the rear of the 5002A or 5003A chassis provides output signals and control functions to drive remote indicators (such as the EAI 5600 or 5620 Series), tape or

$1.15 anything to 20 feet. 78 pin cable with connects on both ends.

TABLE V. Data Outputs

Type of Output	Function	Electrical Characteristics
Binary-Coded Decimal	1, 2, 4, 8 per decade	-6 volts for on, -0.5 volts* for off. Source impedance of each line is about 2700 ohms.
Decimal	0-9 per decade	-7.5 volts for off, -1 volt* for on. Each source can provide up to 1 MA of load current.
Decimal Position	1's, 10's, 100's, or 1000's	-7.5 volts indicates the meter is not in the particular range, -1 volt indicates that the meter is in that range. See Sheet 3 of the applicable schematic (D026 158 0S for the 5002, D026 212 0S for the 5003), terminals P1-43 through P1-46.
Function and Polarity Indication	+, -, AC, KΩ(5003 only)	-7.5 volts indicates the meter is not in the function, -1 volt indicates that the meter is in that function. See Sheet 3 of the applicable schematic, terminals P1-70, P1-71, P1-73 and P1-78 respectively.
Finish-Reading Pulse (Indicator Clear)	Indicates decimal and BCD outputs set to new readings	200 microsecond positive-going pulse (from -7.5 volts to approximately +1.5 volts*).

DPD 78-34P-IL (Cannon)

Saturated transistor.

card punches, or a printer. Table V describes the available outputs. See Sheets 16 and 17 of the applicable wiring list (B026 158 0W for the 5002, B026 212 0W for the 5003), in Volume II of this manual for a complete list of Data Output connector terminations.

e. Control Connector (P4)

The 45-pin connector on the rear of the 5002A or 5003A chassis provides external command control of the TDVM or TDVOM. Functions such as range control and cycle command are available. This connector is jumpered to the 78-pin connector (P1) on the rear of the AC-DC Converter chassis. See Sheet 19 of the applicable wiring list for a complete list of P4 terminations.

f. Control Connector (P1)

This 78-pin connector on the rear of the AC-DC Converter chassis is jumpered to the TDVM or TDVOM control connector. Command signals from the converter (such as range and mode information) and the 115 VAC power supply inputs for the TDVM or TDVOM are terminated at this connector. In addition, the balance line from each of the four AC-DC Converter amplifiers is terminated at this connector. Termination information for this connector is given on Sheets 9 and 10 of Drawing B049 038 0W in Volume II of this manual.

4. PRELIMINARY ADJUSTMENTS

Each 5002 or 5003 is completely checked and factory-calibrated prior to shipment and should require no further adjustment upon receipt. A pre-operational check procedure is outlined in Paragraph 2, Chapter III of this handbook. Performing this check will enable the operator to determine that the instrument is operating properly. If trouble is encountered, refer to appropriate paragraphs in the chapters describing maintenance and calibration.

CAUTION

Calibration adjustments should not be performed unless the operator is certain that the instrument is out of calibration. Calibration of an instrument with accuracy of the 5002 or 5003 requires the use of precision voltage sources and measuring facilities not normally available at field installations.

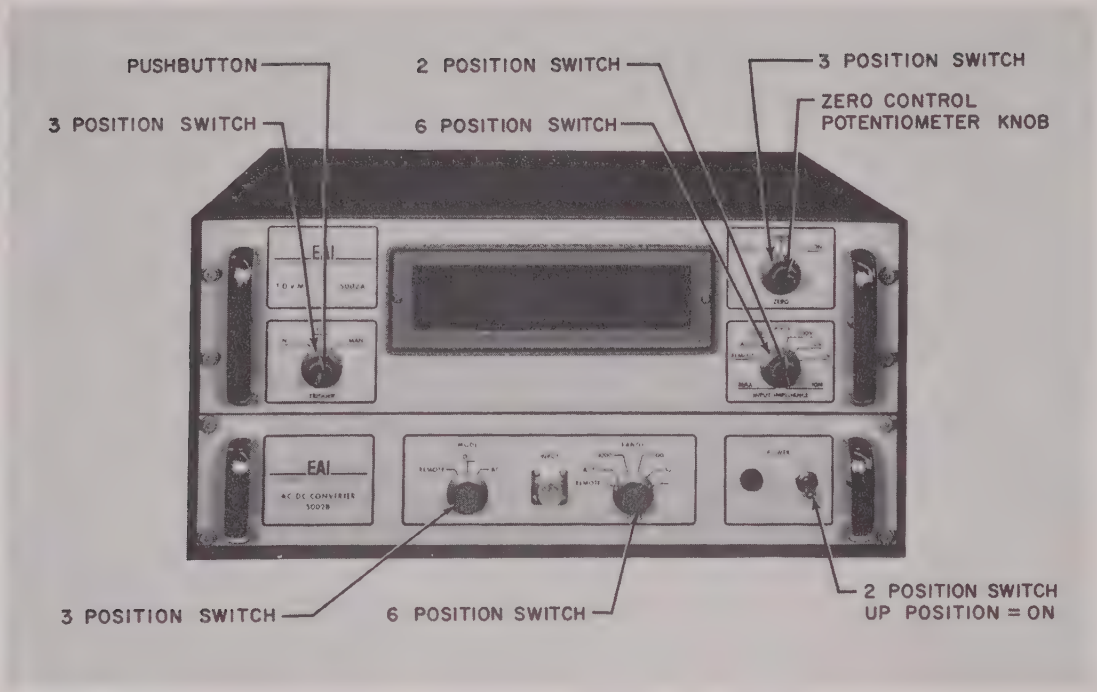
CHAPTER III

OPERATION

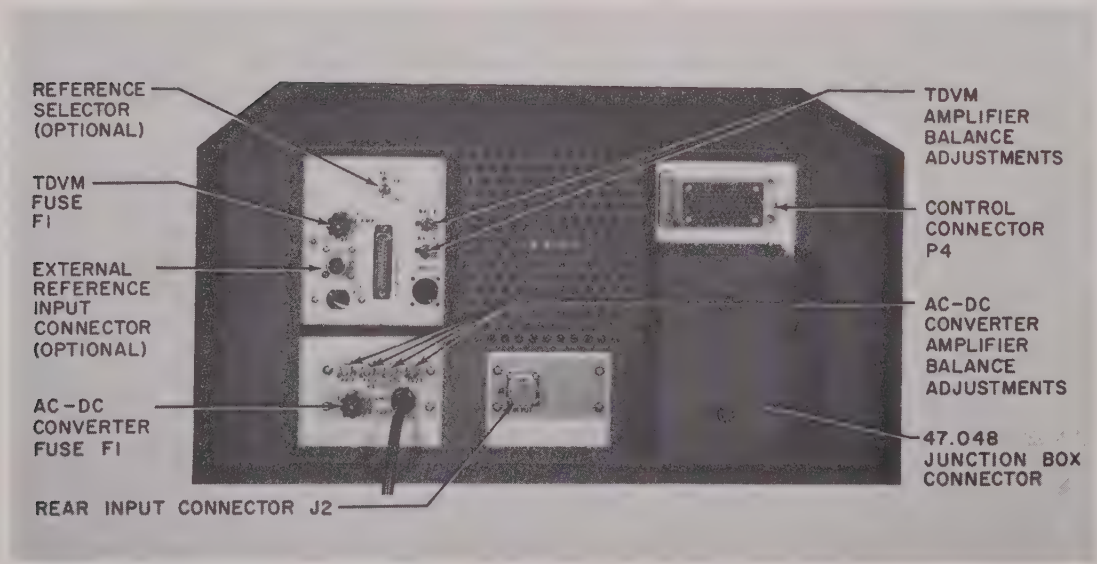
1. CONTROL FUNCTIONS

Before operating either the 5002 or 5003, the operator should be thoroughly familiar with all controls. Each control is listed below with a brief description of its function. The first six controls are on the front panel, the remaining three are on the rear panel. The physical location of each control is shown in Figures 7 and 8.

CONTROL	FUNCTION
OFF STANDBY ON and ZERO control (A chassis)	The light-colored outer portion of this dual control is the OFF STANDBY ON power switch. In the STANDBY position, if the POWER switch on the AC-DC Converter is on, all power supplies are energized but the TDVM or TDVOM input circuits are disabled. In the ON position the AC-DC Converter output, the unknown resistor, or the unknown DC potential (depending upon the mode selected) is applied to the TDVM or TDVOM input amplifier. The dark inner portion is the ZERO control. This control permits zero-setting of the indicators.
RANGE and INPUT IMPEDANCE control (A chassis)	The light-colored outer portion of this dual control is the RANGE switch. This switch is set to the REMOTE position, range switching is controlled by the B chassis RANGE switch. The dark inner position of this control is the two-position INPUT IMPEDANCE switch used with the 1 and 10 volt DC ranges. In the MAX position the instrument offers maximum impedance on these ranges; in the 10M position the 1 and 10 volt DC range impedances are decreased to 10 megohms to conform with the impedance on the 100 and 1000 volt DC ranges.
INT-EXT-MAN and TRIGGER control (A chassis)	The outer light-colored portion of this dual control is the INT-EXT-MAN three-position cycle command function switch. In the INT position the sampling cycle is internally controlled and free-runs at an average sampling rate of 200 readouts per second. In the EXT position an external trigger source can be used to control the sample cycle. In the MAN position the sampling cycle is controlled by the inner dark portion of the dual control; the inner or TRIGGER section is a push-button switch which causes the TDVM to run through a single sampling cycle with each switch depression.



(a) Front View



(b) Rear View

Figure 7. 5002 Series Digital AC-DC Voltmeter, Front and Rear Views

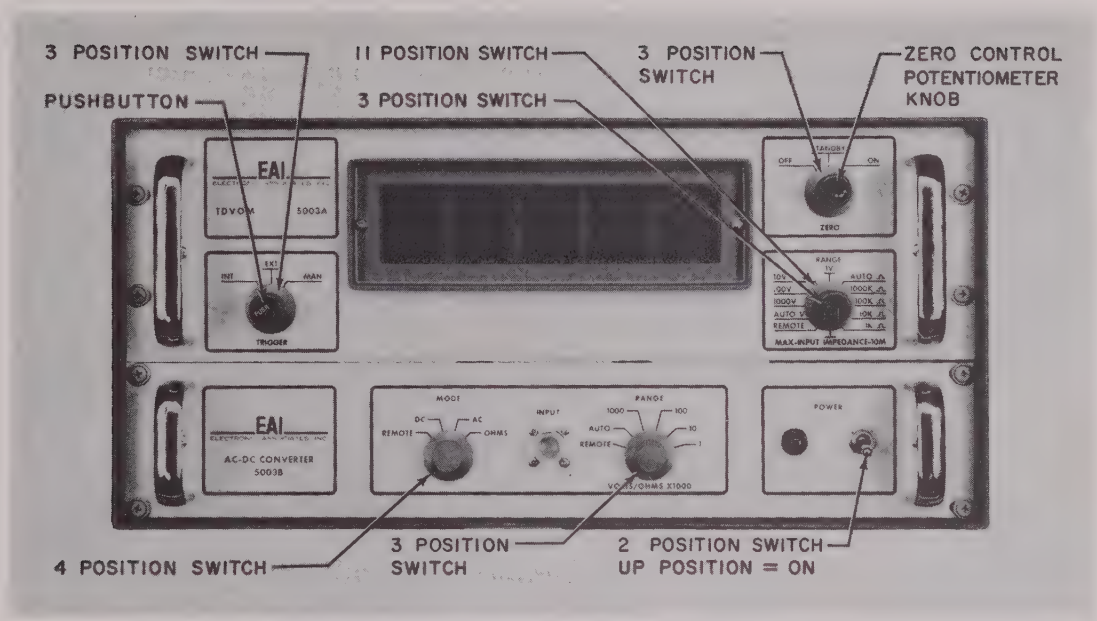


Figure 8. 5003 Series Digital AC-DC Volt-Ohmmeter, Front View

CONTROL	FUNCTION
POWER on-off switch (B chassis)	This toggle switch controls AC power to the 5002 or 5003. In the on position the AC-DC Converter operates normally, and the OFF-STANDBY-ON switch in the TDVM or TDVOM is enabled. The associated indicator lamp lights when the switch is on.
RANGE selector (B chassis)	This switch on the AC-DC Converter chassis is used to select the range. In the REMOTE position, a particular range, or automatic ranging may be selected by an external device. In the AUTO position the proper range is selected by internal circuits, the other positions permit manual range selection.
MODE selector (B chassis)	This switch determines the test instrument mode of operation. In the REMOTE position the mode is controlled by external equipment. In the AC position the AC-DC Converter is used, in the DC or OHMS (5003 only) position the converter is by-passed for DC or ohms measurements.
INT-EXT-REF (optional on A chassis)	This toggle switch permits selection of an external reference source for the TDVM or TDVOM (EXT position), or normal use of the internal reference source (INT position).
BAL A, BAL B (A chassis)	TDVM or TDVOM amplifier balance controls. (See Paragraph 2.)
BAL POTS AR1B, AR1A, AR2B, AR2A (B chassis)	AC-DC Converter amplifier balance controls. (See Paragraph 2.)

2. PRE-OPERATIONAL CHECKS

The procedures outlined in this paragraph are recommended for use as a pre-operational check and for periodic preventive maintenance purposes after the instrument is in service. These checks are relatively simple to perform and serve to indicate that the instrument is functioning properly. (If trouble is encountered refer to appropriate sections of this handbook for maintenance and calibration procedures.)

a. Prepare the unit for operation by connecting the power cord to an appropriate AC source. Turn the AC-DC Converter POWER switch on, and set the TDVM or TDVOM switch to STANDBY. Allow the instrument to warm up for 30 minutes.

b. Set the B chassis RANGE switch to 10V.

c. Connect a multimeter (Tripplet Model 630A or equivalent) set to the 60 volt range between pins 16 (±ground) and 17 of the TEST POINTS connector. Rotate the BAL-B potentiometer for a minimum reading. Decrease the range until a null is obtained on the 3 VDC range.

d. Switch the multimeter to the 60 microamperes range and again adjust BAL-B for a minimum reading.

e. Connect the multimeter between pins 16 and 18, and repeat Steps *c.* and *d.* adjusting BAL-A.

f. Connect the multimeter between pins 1 (±ground) and 44 of the Control connector (P1) on the rear of the AC-DC Converter chassis. Repeat Steps *c.* and *d.* adjusting R1.

g. Connect the meter between pins 1 and 45 and repeat Steps *c.* and *d.* adjusting R2.

h. Connect the meter between pins 1 and 46 and repeat Steps *c.* and *d.* adjusting R3.

i. Connect the meter between pins 1 and 47 and repeat Steps *c.* and *d.* adjusting R4.

j. Set the MODE switch to DC, the RANGE switch to the 10 volt position, the OFF-STANDBY-ON switch to ON, and rotate the ZERO control until the indicators display 00000. (If the polarity relay begins to chatter turn the ZERO control slightly clockwise until the chatter stops and the indicator displays 00000.)

k. Connect a variable DC voltage source (capable of supplying potentials of 0 to ±130 volts) to the input connector; set the TDVM or TDVOM RANGE switch to the AUTO position. (The DC source must be stable.)

l. Set the DC source for a positive output of less than 1 volt. Set the INPUT IMPEDANCE selector switch to 10M. Slowly vary the input voltage and check for proper counting sequence on one range. Make sure that the unit switches ranges when the input is raised above a reading of 11999. Reverse the input polarity; observe that the polarity indicator changes.

m. Manually switch the instrument to the 10 volt range. Apply a positive or negative potential. Observe that the overload lamp starts to flicker as the input rises above 11.999 volts.

n. Adjust the DC source for 1 volt input. Change the MODE switch to AC. The indicators should display 1.1107.

If the unit operates as described in the preceding steps and no troubles are encountered, the instrument is ready for service.

3. NORMAL OPERATION

The 5002 and 5003 are relatively simple to operate using the front panel controls described in Section 1 of this chapter. A brief procedure for using the instruments in each mode of operation is given below. (The amplifiers should be balanced and the instrument zero set as described in Paragraph 2 prior to using the instrument.)

a. DC

(1) Set the MODE switch to DC.

(2) Set the TDVM or TDVOM RANGE switch to REMOTE.

(3) Set the AC-DC Converter RANGE switch to the desired range; REMOTE if external range selection is desired.

CAUTION

Overload voltages of 500 volts or more applied to the unit when the RANGE switch is on either the 1 or 10 volt ranges may permanently damage the precision input resistor network. This unit is sealed; if damaged it must be returned to EAI for repair or replacement. When using manual ranging, always start on the 1000 volt range for unknown inputs.

(4) Set the TRIGGER and INPUT IMPEDANCE selectors to the desired positions. The unit is now set for DC operation.

b. Ohms (5003 Only)

(1) Set the MODE switch to OHMS.

(2) Set the TDVOM RANGE selector to REMOTE.

(3) Set the AC-DC Converter RANGE selector to the desired range.

(4) Set the TRIGGER switch to INT.

(5) Short the input leads and adjust the ZERO potentiometer for a reading of 0000.

(6) Set the TRIGGER switch to the desired setting.

The 5003 is now set for ohms operation.

c. AC

(1) Set the MODE switch to AC.

(2) Set the AC-DC Converter RANGE switch to AUTO or the desired range.

(3) Set the TDVM or TDVOM RANGE switch to REMOTE.

(4) Set the TRIGGER switch to the desired setting.

The unit is now set for AC operation.

CHAPTER IV

THEORY OF OPERATION

1. INTRODUCTION

This chapter describes the theory of operation of the 5002 and 5003. Since the 5003A TDVOM is simply a 5002A TDVM with four ohm scales added, the 5002A is described first. The ohms circuits and the AC-DC Converter are described in subsequent sections.

2. 5002A TDVM

The 5002A TDVM utilizes the programmed-comparison type of meter circuit where the current produced by the unknown or input voltage is compared to a known reference current. The indicators display a voltage (in decimal equivalent) proportional to the magnitude of the reference that is required to null the unknown current.

a. Block Diagram Analysis

Figure 9 is a simplified block diagram illustrating the operation of the 5002A TDVM. The unknown voltage is applied to the dual DC amplifier and input circuits which provide proper scaling and isolation of the input. The scaling of the input permits the TDVM to handle the wide range of input voltages on the four range scales and maintain the required accuracy within each range. The dual DC amplifier circuit permits selection of a positive representation of the input signal for application to the comparator amplifier summing junction regardless of the actual unknown polarity.

The positive polarity representation of the unknown is applied to the comparator amplifier summing junction where it is compared to a negative reference signal of known magnitude. The two signal currents (summed algebraically) form the input signal to the comparator amplifier. The comparator output (or difference signal) is determined by which of the two input signals at the summing junction is larger. This output does not indicate the *magnitude* of the difference but merely which is the *larger* of the two.

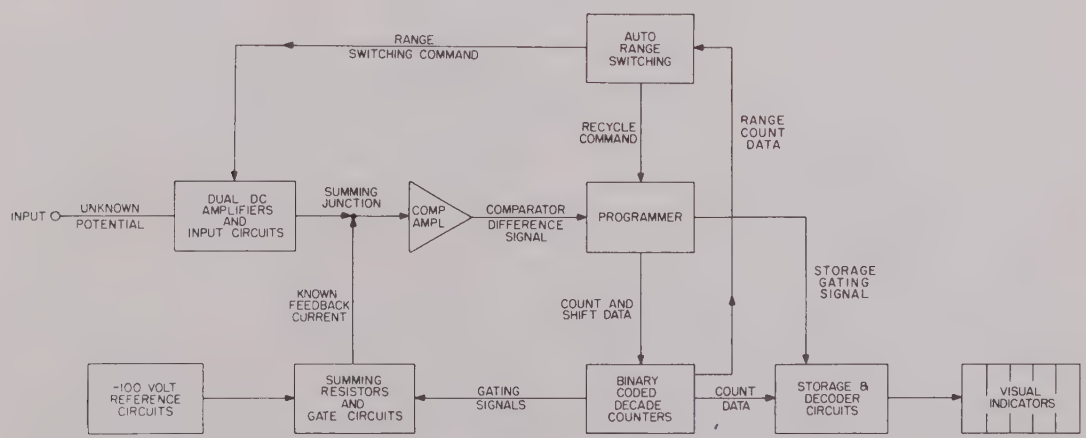


Figure 9. 5002A TDVM, Simplified Block Diagram

The comparator difference signal is sent to the programmer which in turn determines the counting instructions that are sent to the decade counters. The programmer data instructs the counters to increase or decrease the known feedback current to the summing junction based on the signal from the comparator amplifier.

In the automatic ranging mode the decade counter data is sampled by the auto range switching circuit. Dependent on the counter data the auto range circuit either permits the sampling cycle to continue (unit on proper range) or stops the cycle and up or down ranges the instrument as indicated by the count data. If range switching is required the auto range switching circuit also re-cycles the programmer so it re-starts at the beginning of the sampling cycle on the new range. In addition to its function of range switching in the automatic mode the auto range switching circuit also serves as an overload protection circuit for manual range selection. If the selected range is too low for the input voltage, the auto range switching circuit stops the sampling cycle and lights a red lamp in the extreme left-hand visual-indicator section. The instrument is momentarily switched out of the under-range setting thus protecting the precision input resistors. The instrument will return to the original range if the setting is not manually changed; however, the auto circuit instantaneously switches it out again if the overload still exists. This switching action will continue, and the red overload lamp will flicker until the unit is either up ranged (manually) to a proper setting or the over-voltage input is removed.

When the proper range is obtained the programmer is released to instruct the counters to increase or decrease the known feedback current as previously mentioned.

The counters indirectly control the feedback current by binary-coded decimal voltage gating-signals applied to summing resistor gate circuits. The gating circuits in turn directly control the current flow from the -100 volt reference circuits to the summing junction in known binary-coded decimal steps. When the known reference current and the current due to the unknown are equal in magnitude the programmer stops the decade counter operation. The decade counters then contain, in binary-coded decimal form, the magnitude of the known current required to null the unknown current.

Storage gating instructions from the programmer (generated when the two currents are nulled) release previously stored data from the storage circuits and permit the insertion of the new binary-coded decimal count data. In addition these storage instructions hold the new data in the storage circuit thus permitting the release of the decade counters for a new sampling cycle of the input unknown.

The storage circuits apply the binary-coded data to decoder circuits which convert this data to numeric decimal notation. The numeric decimal data is applied to the indicators, illuminating the proper digits. The displayed digits are actually a scaled representation of the potential required to produce the known current, and because the known and unknown currents are equal in magnitude, it is a numeric representation of the unknown voltage *magnitude*. The indicators also display the polarity of the unknown (determined during the sign check cycle) and the decimal point location (determined by the range setting).

The entire sequence of events (polarity or sign check, magnitude evaluation and display) takes an average of 5 milliseconds when a range or polarity change is not involved. The actual time required to sample and display a given voltage may be calculated in the following manner. Assume that a clock pulse is generated by the blocking oscillator every 1/5 millisecond. It takes six of these clock-periods, regardless of the magnitude of the unknown voltage, to shift through the various counters (1000's through 1's) and to display the data. In addition it requires 1 clock-period for each digit of the magnitude from 1 to 9, plus the sign check time. As an example, if 12.48 volts (either positive or negative) is applied to the TDVM, in addition to the six required clock-periods 15 more clock-periods are required (1 clock-period for the 1 digit, 2 for the 2 digit, 4 for the 4 digit, and 8 for the 8 digit) or a total of 21 clock-periods. This total of 21 does not include that time required for the sign check; thus a total time of 4.2

milliseconds is required for the sampling cycle less the sign check time. If the signal polarity does not change, the sign check period is 1/5 millisecond and the entire operation takes 4.4 milliseconds. It takes about 25 milliseconds to operate the polarity relay (energize or de-energize); thus if there is a sign change (positive to negative input or vice versa) the operation takes about 4.2 + 25 or 29.2 milliseconds.

b. Functional Diagram Analysis

Schematic Diagram D026 158 0S, Sheets 1 through 3 (Volume II) is a functional logic diagram of the 5002A TDVM and is used as the basis of this description. The sampling operation of the TDVM may be considered to take place in three steps: the sign check cycle, the magnitude evaluation cycle, and the storage and display cycle. The automatic range selection operation may be considered as part of the magnitude evaluation cycle. To simplify the description of the TDVM operation, however, the auto range switching circuit is described separately, as are the various special feature circuits such as the external or manual trigger circuit. This functional description is therefore divided into four separate sub-divisions. Three divisions, the sign check cycle, the magnitude evaluation cycle, and the storage and display cycle, are described assuming the instrument is in the proper range, that range switching is not required, and the instrument is set for internal triggering (free running). The fourth division describes the auto range switching circuit and its subsequent effect on the three operating steps in the TDVM, should range switching be required.

For the following description assume the TDVM is properly ranged, has sampled, and is displaying a voltage value or +12.48 volts. Approximately 200 times a second the TDVM samples this applied voltage (average sampling time) thus keeping a constant check on actual voltage magnitude. After each of the sampling cycles the display is extinguished and the new sampled value displayed in its place. It takes about 1/5 millisecond to extinguish and replace the display; therefore, if the input does not vary, the display appears as if constantly illuminated.

Figure 10 is a timing diagram showing the voltage pulses at strategic points throughout the TDVM (portions of this diagram are exaggerated for clarity). The diagram is scaled across the top in intervals of time; each interval is equal to approximately 1/5 of a millisecond (0.0002 seconds). (This diagram is drawn in accordance with the assumption that range switching is not necessary.) The diagram starts at time t_0, the instant at which a new sampling cycle is started. The first step of the new sampling cycle is the sign check.

(1) *Sign Check Cycle.* The TDVM is designed to function with a positive representation of the unknown input voltage applied to the comparator summing junction (regardless of the actual unknown polarity). The purpose of the sign check cycle is to assure that this condition is fulfilled before the actual sampling of the input unknown is attempted. In addition, the sign check cycle assures that the visual indicator displays the actual polarity of the unknown.

To assure the application of a positive polarity to the comparator, a relay (K1) is used at the output of the dual DC amplifier (Figure 11). This relay permits the selection of the amplifier output from either the first section (b) or the second section (a) of the dual amplifier. If the input unknown is negative, taking the output from amplifier (b) provides the required positive representation for application to the comparator. If the unknown is positive, however, polarity relay K1 must be energized and the output of amplifier (a) used to provide the required positive representation.

During the sign check cycle the TDVM must determine if the polarity relay, K1, is in the proper state; i.e., energized for positive unknown inputs and de-energized for negative potential unknown inputs. To determine if the relay is in the proper state the reference current is removed from the comparator summing junction so the summing junction is controlled by the unknown potential only. If the unknown representation is positive, K1 is in the proper state; if the unknown is negative, K1 must be reversed.

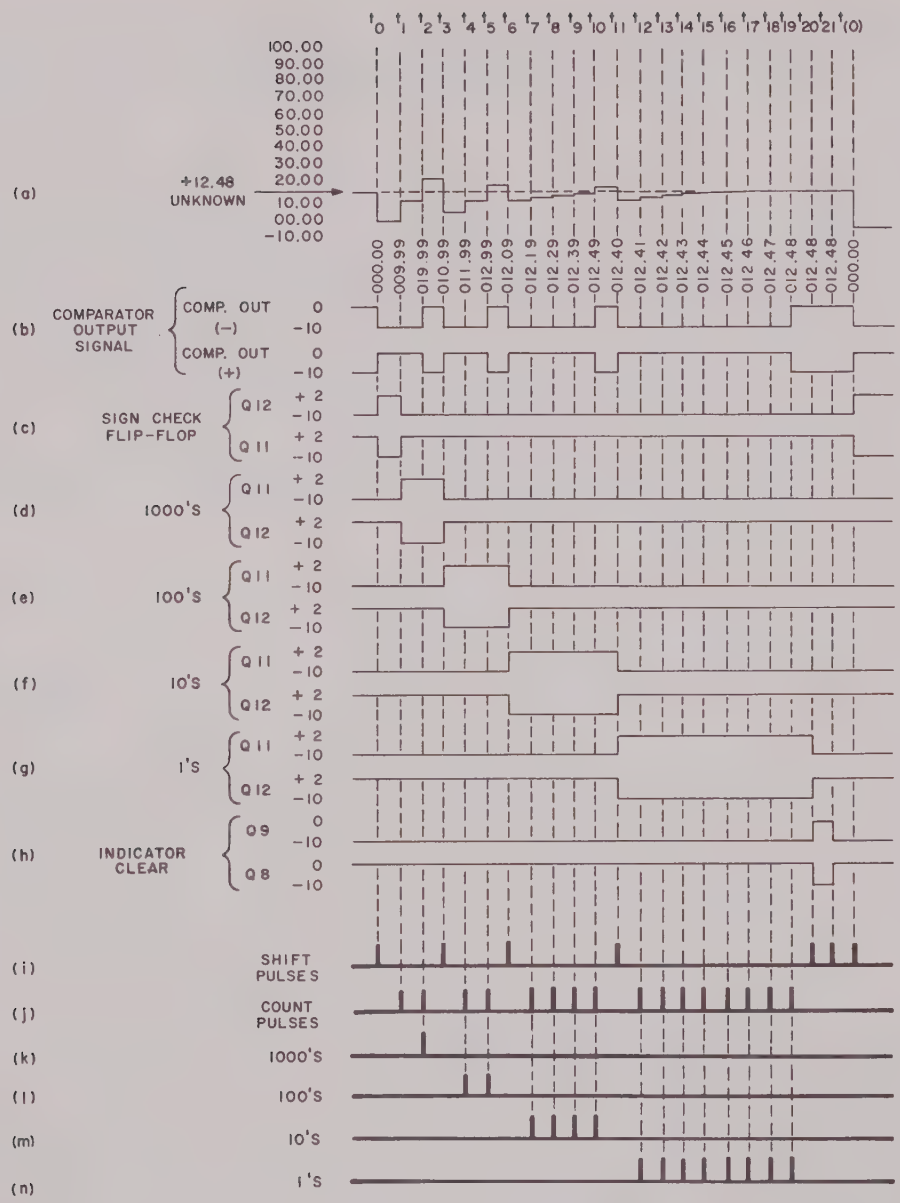


Figure 10. TDVM Timing Diagram

The sign check cycle starts at the time t_0 as shown on the timing diagram, Figure 10. At time t_0 the TDVM has completed its previous sampling operation and the unit is set to start a new sampling cycle. This new sampling operation is started (at t_0) when a clock pulse from the blocking oscillator triggers the sign check multivibrator (Q11 and Q12, Figure 12 and curve c, Figure 10). Q11 is cut off and generates a negative voltage which is routed out pin J of the programmer card to the zero-set transistor (Q10) on each of the four binary-coded decade counter (BCD) cards (D026 158 0S, Sheets 2 and 3). Q10 on each of the BCD cards sets the

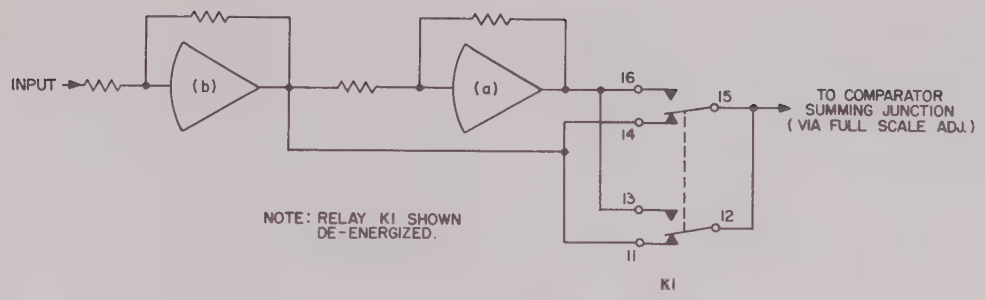


Figure 11. Dual DC Amplifier and Polarity Relay, Simplified Schematic Diagram

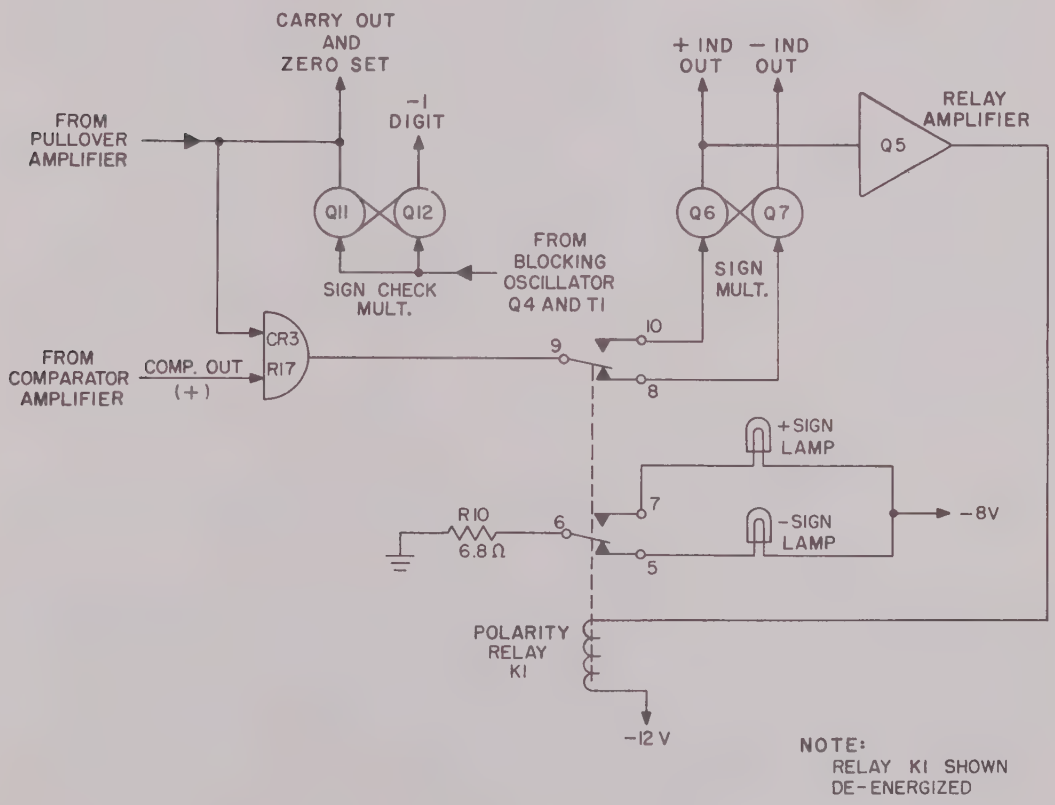


Figure 12. Sign Check Circuit, Simplified Logic Diagram

circuit to a zero count. Since the BCD cards control the reference current applied to the comparator summing junction (via diode gating), zero-setting the cards removes all reference current from the comparator summing junction. At time t_0, therefore, the comparator summing junction is controlled by the unknown voltage representation from the output of the dual DC amplifier.

The comparator amplifier is a five stage transistor amplifier with outputs taken from the fourth and fifth stages (Q4 and Q5 respectively). The output at Q4 is designated *Comp Out* + and from Q5, *Comp Out* - (D026 158 0S, Sheet 1). The operation of the comparator is such that if the input is positive Q4 is saturated (collector at zero), and Q5 cut off (collector at -10 volts). A negative input reverses the situation, i.e., Q4 cut off, Q5 saturated. Thus, the *Comp Out* + lead essentially indicates the polarity of the signal applied to the comparator as follows: if the comparator input is positive the *Comp Out* + lead is at zero, if the comparator input is negative the *Comp Out* + lead is at -10 volts. The voltage on the *Comp Out* + lead between time t_0 and t_1 is used to indicate to the programmer whether or not relay K1 is in the proper state. The *Comp Out* + potential is applied to an AND circuit in the programmer (CR3 and R17) along with the negative pulse from Q11 of the sign check multivibrator (Figure 12).

Both inputs to the AND circuit must be negative to produce an output. Since the input from the sign check multivibrator (Q11) is always negative during the sign check cycle the operation of the AND gate is controlled by the *Comp Out* + lead which is only negative when the polarity relay is in the *improper* state. Thus, during the sign check cycle, if a negative potential is applied to the comparator summing junction a pulse is passed through the CR3-R17 AND gate in the TDVM programmer. If a positive input is applied to the summing junction during this period, however, (*Comp Out* + lead at 0) no pulse will pass through the AND gate.

If a pulse passes through the AND gate it is applied to either Q6 or Q7 of the sign multivibrator depending on the state of K1. As shown in Figure 12, with K1 de-energized, the pulse is applied to Q7 triggering it into conduction. This action cuts off Q6, its collector drops to -10 volts and Q5 conducts energizing the relay. Contact K1-9 then closes with K1-10. Note that K1-9 is always connected to the side of the sign multivibrator which is cut off, i.e., K1-9 contacts K1-8 when Q7 is cut off (Q6 conducts and K1 is de-energized), K1-9 contacts K1-10 when Q6 is cut off (K1 is energized). Therefore, any time a pulse is passed through the AND gate (indicating K1 is in the wrong state) the sign multivibrator is triggered to the opposite state reversing the condition of K1.

Contacts K1-5, 6, and 7 control the polarity indicator lamps in the visual display unit. When K1 is de-energized the negative lamp lights; when K1 is energized the positive lamp lights.

The output of Q12 of the sign check multivibrator during the sign check cycle is applied to the summing junction of the comparator. This low-level signal will only effect the circuitry on a zero or extremely low-level input signals when it functions to prevent polarity-relay chattering.

As previously stated, in this description it is assumed the instrument has sampled and displayed +12.48 volts and that the sampling operation being described assumes the +12.48 volts is still applied to the instrument. Under these conditions K1 is energized and at time t_0 the proper positive representation of the unknown is applied to the comparator summing junction. No pulse can pass through the AND gate (*Comp Out* + lead at 0) and the relay remains in the energized state. When a change of the relay condition is not required the sign check cycle takes approximately 1/5 millisecond to complete. A change in the relay state, however, (polarity reversal at the input), requires a minimum of 10 milliseconds. The purpose of this minimum delay is described in Sub-Paragraph (4).

At time t_1 (Figure 10) the sign check cycle is stopped (assuming K1 is not reversed) when the next blocking oscillator pulse triggers the sign check multivibrator back to its original state (Q11 conducts, Q12 cut off). At time t_1, therefore, the TDVM starts the second phase of operation, the magnitude evaluation cycle.

(2) *Magnitude Evaluation.* Up to this point the TDVM has checked the polarity of the unknown and assured that a scaled positive representation of this potential is applied to the comparator. In addition the unit registers the polarity of the unknown on the visual readout indicators. During the magnitude evaluation phase of the sampling operation the TDVM brings the known reference current level applied to the comparator summing junction into agreement with the current due to the unknown potential.

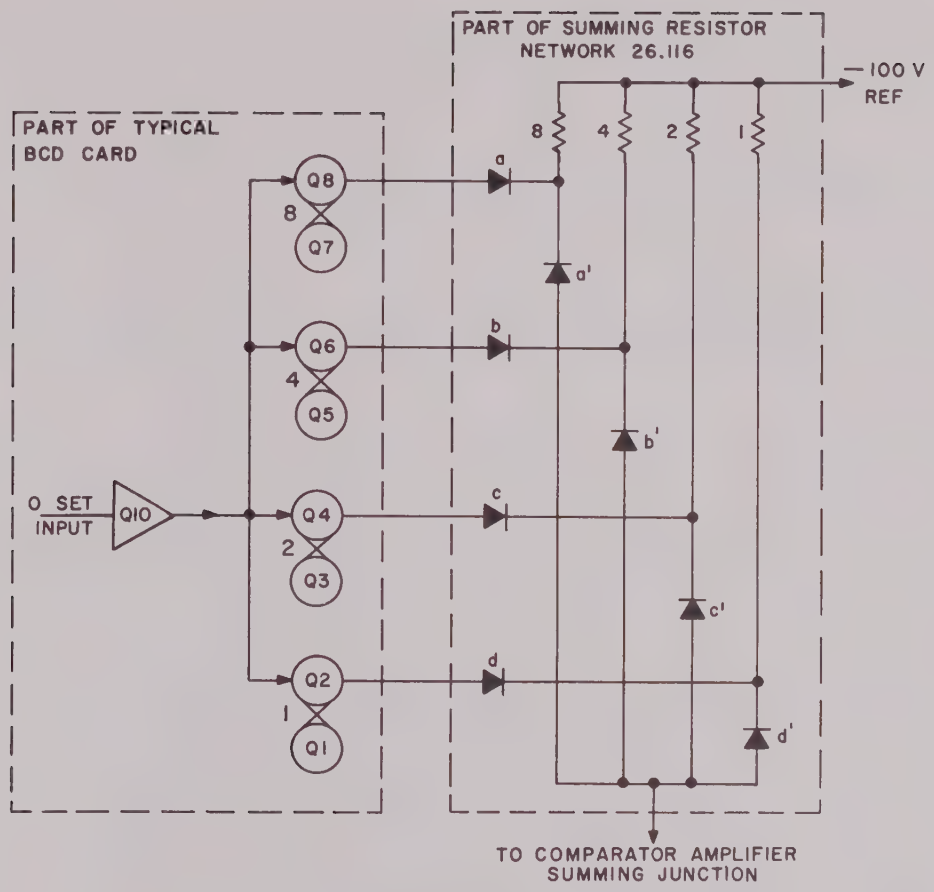


Figure 13. Typical BCD and Diode Gate Circuit, Simplified Logic Diagram

Figure 13 illustrates how a typical BCD card controls the known reference current flow to the comparator summing junction. When a BCD registers a binary-coded 0, all of the counter multivibrators (designated 1, 2, 4, and 8 on Figure 13) are set in the *1* state, i.e., Q2, Q4, Q6, and Q8 conducting. These transistors apply a positive potential to the anodes of the diodes designated a, b, c, and d which in turn back-biases a', b', c', and d' respectively. Thus current flow through resistors 1, 2, 4, and 8 cannot pass through the back-biased diodes to the comparator summing junction. If, however, any of the counters are set in the *0* state (odd transistor conducting) the corresponding diode of the *0* state counter (a, b, c, or d) is back-biased. This removes the back-bias from the corresponding primed diode and permits current to flow from the -100 volt source, through the associated resistor, to the summing junction.

The resistors are matched such that the current flow relationship with respect to each other is in binary-coded decimal steps. Each BCD controls a set of four resistors and these sets are matched with respect to each other on decimal relationship such that the units BCD set is 10 times that of the tens set, 100 times that of the hundreds set and 1000 times that of the thousands set. This permits the counters to control the reference current flow to the comparator amplifier summing junction in four decimal groups of binary-coded decimal steps of known magnitude. When the known current is in agreement with the unknown (in magnitude), the magnitude of the unknown is recorded in the BCD count.

Figure 13 also shows the 0-set transistor Q10; at time t_0 when Q11 of the sign check multivibrator triggers this circuit the BCD card is set to a zero count. Each BCD contains a 0-set circuit; thus, at time t_0 all reference current is removed from the comparator summing junction.

At time t_1 the magnitude evaluation starts when the sign check multivibrator reverses its state (due to a pulse from the blocking oscillator). The collector of Q11 (of the sign check multivibrator) goes slightly positive; this positive potential reverses the state of the 1000's multivibrator (Q11 and Q12) on the 1000's binary-coded decimal counter. (D026 158 0S, Sheet 3.)

In reversing the state of the 1000's multivibrator (Figure 10) a positive potential is applied to the anode of diode CR21 (Figure 14). This biases CR21 so the count pulses (added to this bias voltage) are sufficient to trigger the 1's counter multivibrator (Q1 and Q2). If Q11 is cut off and a negative potential is applied to the anode of CR21 the count pulses at this time are not of sufficient magnitude to trigger the counters.

At time t_1 only Q11 of the 1000's multivibrator is set to the proper state; thus, only the 1000's decade counter can react to the count pulses. The negative pulse generated by Q12 at this time is applied to the 9-set transistors (Q9) of the 100's, 10's, and 1's counter (D026 158 0S, Sheet 3). The 100's, 10's, and 1's decade counter cards are each set to a nine count (Q2 and Q8 cut off) permitting current representing a 999 count to flow to the summing junction from the reference source. This is equivalent to applying current from a -9.99 volt source to the summing junction when the meter is on the 100 volt range (as is necessary to measure +12.48 volts).

In addition to 9-setting the remaining counters, the negative potential from the collector of Q12 (of the 1000's multivibrator) is applied through diode CR14 to the base of the pullover inverter (Q10) on the programmer card. The pullover inverter *locks the sign check multivibrator* (Q11 conducting, Q12 cut off) *preventing it from being triggered during the evaluation cycle.*

At time t_1 to t_2 current at the summing junction of the comparator amplifier is controlled by two voltage sources: the scaled positive representation of the unknown input (+12.48 volts) and the scaled equivalent of -9.99 volts from the negative reference source. Between times t_1 and t_2, therefore, the positive unknown potential, being larger, controls the comparator summing junction current, and Q1 of the comparator is cut off. This causes the *Comp Out* + line to be at ground potential and the *Comp Out* - line to be at -10 volts.

The *Comp Out* + and *Comp Out* - leads are connected to Q1 and Q2 of a double AND gate (D026 158 0S, Sheet 2). Pulses from the blocking oscillator are continually applied to both of these transistors via emitter follower Q3. Q3 functions to isolate the blocking oscillator to prevent loading that circuit.

Either Q1 or Q2 passes the blocking oscillator pulses if the corresponding *Comp Out* lead connected to that transistor is negative. At time t_2 the *Comp Out* - lead is negative; thus Q2 passes the blocking oscillator pulse. The output of Q2 forms the count pulses and these are sent to all of the binary-coded decade counters. The 1000's counter is the only unit released for counting at time t_2; therefore, it registers a *1* count. This increases the known current flow to the summing junction to a value equivalent to -19.99 volts. At time t_2 then, the known current becomes larger than the unknown (+12.48 volts). The comparator summing junction comes under the control of the negative current source and the *Comp Out* + line goes to -10 volts*.

The -10 volts on the *Comp Out* + lead permits the blocking oscillator pulse at time t_3 to pass through Q1 of the double AND circuit. This is the TDVM *shift* pulse. The *shift* pulse (a positive pulse) is applied to Q11 of the 1000's, 100's, 10's, and 1's multivibrators (D026 158 0S, Sheet 3 and Figure 14). Q11 of each multivibrator is cut off in each case, with the exception of the 1000's

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**Although the Comp Out + lead is at -10 volts this does not affect the sign multivibrator because the sign check multivibrator is locked by the pullover inverter.*

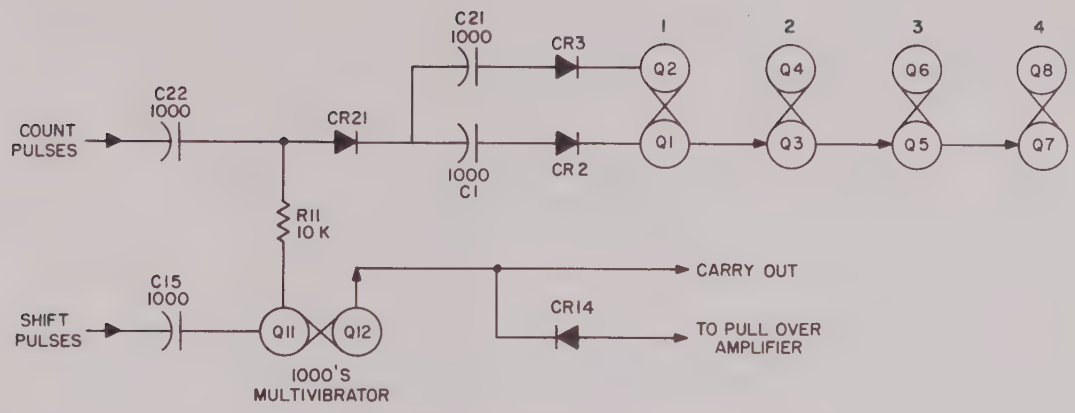

Figure 14. Typical BCD Count and Release Circuit, Simplified Logic Diagram

multivibrators. The *shift* pulse only effects the 1000's multivibrator and triggers this circuit to its opposite state (Q11 cut off, Q12 conducting). As Q12 conducts, the collector voltage goes in a positive direction; the positive voltage is applied to Q12 of the 100's multivibrator triggering this circuit to its opposite state.

Triggering the 100's multivibrator releases the 100's counter for counting. In addition the negative-going voltage of Q12 of the 100's multivibrator (curve *e* of Figure 10) is applied to the 100's zero-set transistor (Q10) setting the 100's counter to zero. This changes the apparent negative potential applied to the comparator summing junction from -19.99 volts to -10.99 volts. The current due to the +12.48 volt representation of the unknown regains control of the summing junction. The *Comp Out* - lead becomes -10 volts and the next blocking oscillator pulse generates a *count* pulse.

The negative potential from the collector of Q12 (100's multivibrator) is applied to the base of the pullover inverter. Thus, even though Q12 of the 1000's counter is conducting, the negative potential from Q12 of the 100's counter prevents the sign check multivibrator from being triggered.

At time t_4 the blocking oscillator pulse is passed through Q2 of the double AND circuit and sets the 100's counter to one. The known current at the summing junction becomes equivalent to -11.99 volts. The unknown voltage representation (+12.48 volts) is still larger however; thus at time t_5 a second count pulse is generated. The 100's counter is set to a two-count (curve *l*, Figure 10) and the negative or known voltage equivalent becomes -12.99 volts. With the known current controlling the summing junction a *shift* pulse is generated at time t_6. The *shift* pulse sets the 10's counter for counting and locks the 100's counter.

The counting process continues in a similar manner as until time t_{19} when the known and unknown current are in agreement (in magnitude). At this time the summing junction goes under control of the negative potential of the zero set potentiometer R2. The *Comp Out* + lead is therefore at -10 volts at time t_{20} and a *shift* pulse is sent from the programmer. This *shift* pulse reverses the state of the 1's multivibrator, stopping the counting cycle and starting the conversion and display cycle.

(3) *Conversion and Display Cycle.* Up to time t_{20} the TDVM has checked the polarity of the unknown, illuminated the proper visual readout sign indicator and brought the reference feedback current magnitude into agreement with the unknown current magnitude. Since the magnitude of the reference current is controlled by the BCD cards, the BCD count must also be an indication of the unknown input magnitude. During the conversion and display cycle the BCD

count is transferred to the readout storage decade (RSD) cards for storage and conversion to arabic decimal for display on the visual readout. Storage of the BCD count in the RSD cards permits clearing (or zero-setting) the BCD card so a new sampling operation can be made while the previously attained value is held and displayed.

As previously stated the conversion and display cycle starts at t_{20} when a *shift* pulse from the programmer reverses the state of the 1's multivibrator (curve *g*. Figure 10). The positive collector voltage of Q12 of the 1's multivibrator is applied to Q8 of the indicator clear multivibrator on the programmer card cutting it off and applying its negative collector potential to the pullover inverter, maintaining it in the conducting state; thus the sign check multivibrator is held in the locked condition.

The positive collector voltage of Q9 of the indicator clear multivibrator is the actual clearing signal. This signal is applied to the indicator clear gate Q3 (on the Network Card, C012 687 0S) cutting it off (Figure 15). Transistor Q3 in its normally conducting state forward-biases the gating diodes on the RSD cards (CR5, 13, 14, 21, 22, 29, 30, and 36 on Figure 15 and Schematic Diagram D051 010 0S)*.

The forward biased diodes prevent the operation of the BCD cards from affecting the RSD multivibrators during the sampling operation. At time t_{20} when Q3 is cut off (reverse biasing the diode) the state of the BCD counters triggers the corresponding RSD multivibrators in a similar but opposite state. As an example, Figure 15 shows the collector voltages of the BCD and RSD multivibrators in parenthetical notations (where + = 0 volts and - = -10 volts) for a binary-coded eight. Note that the collectors of the RSD multivibrators are opposite to those of the BCD counters.

At time t_{21} the blocking oscillator triggers the indicator clear multivibrator back to its original state (Q8 conducting, Q9 cut off). This permits the indicator clear gate Q3 to conduct and locks the RSD multivibrators with the new count so subsequent action of the BCD counters can not effect them. At the same time the pullover inverter is released; thus, at time t_{22}, shown as $t_{(0)}$ on Figure 10, the sign check indicator is released so the blocking oscillator pulse can zero-set the counters and the TDVM can start a new sampling operation.

Figure 16 is a logic diagram illustrating the conversions of the binary-coded decimal data to arabic decimal. Following through with the binary 8 used in Figure 15 the plus and minus parenthetical notations in Figure 16 indicate 0 and -10 volts respectively.

The AND gates shown in Figure 16 correspond to the diodes of Schematic Diagram D051 010 0S. Note on the schematic that the base of each of the drivers (Q1 through Q10) is connected to the -8 volt supply and will conduct *unless* one or more of the diodes is forward biased. Thus for a driver to conduct and illuminate its corresponding digit lamp each diode of its base AND circuit must be reverse biased; i. e., for the 8 digit to light (Q9 conducting) the 8' and 1 inputs to the Q9 AND circuit of Figure 16 *must both be negative* and at least *one* of the inputs to all the other AND circuits must be *positive*. Studying the parenthetical notations of Figure 16 shows that this is true. (Note that because of the previously mentioned reversal of collector potentials between the BCD counters and the RSD multivibrators that the 1, 2, 4, and 8 outputs are used instead of the 1', 2', 4', and 8' to indicate a zero, and similarly 8' and 1 indicate an 8.)

Figure 17 is a simplified logic diagram for the 51.080 RSD card. This card is essentially a modification of the 51.010 Card; the modification permits the card to store and read out the additional 10,000's count necessitated by the 20 percent overrange capabilities of the instrument. Note the similarity in logic between Figures 16 and 17; differences in logic are directly

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**Due to the similarity of operation between the 51.080 and 51.010-1 Models of the RSD card only the operation of the 51.010-1 is used in this description.*

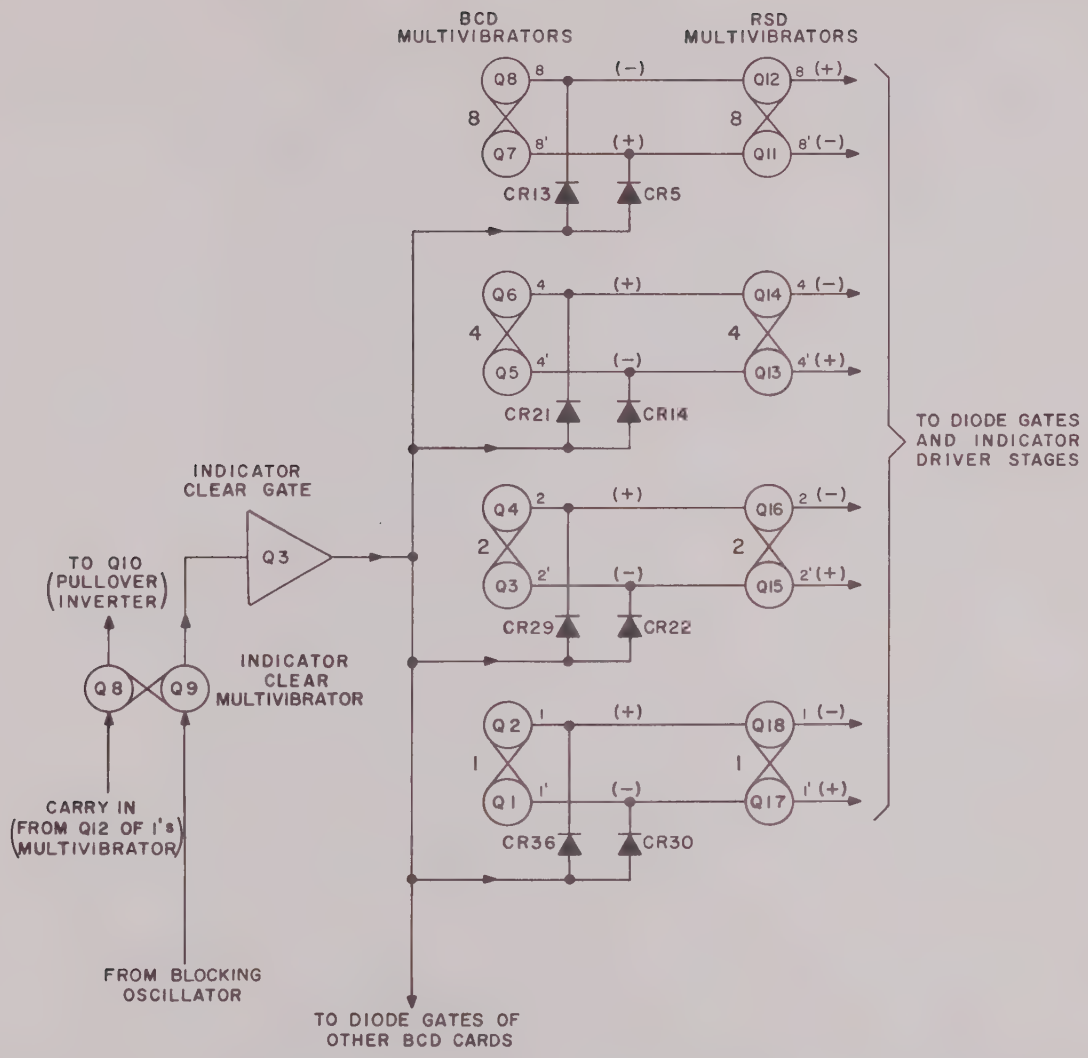


Figure 15. Typical Indicator-Clear Gating Circuit, Simplified Logic Diagram

related to the overrange capability. As an example, the 9-driver AND circuit of the 51.080 RSD uses the *2* intelligence in addition to the 8' and 1' as used by the 9-driver AND circuit of the 51.010 RSD. The additional *2* prevents the 51.080 9-Driver from conducting when an eleven count is registered. The 0 and 1-driver inputs are extensively modified on the 51.080 RSD due to the necessity of Q11 being required to conduct on both a 0 and 10 count and the Q12 requirement for both a 1 and 11 count.

In the case of an increasing gradient voltage where the ramp is extremely steep, or a voltage in which there is a sudden rise in magnitude, it is possible for the voltage to rise above the sampling point before the magnitude evaluation is complete. As an example, assume that the meter starts a sampling cycle when the unknown is equal to 12.00 volts in magnitude. Assume that a sudden rise in potential places the input magnitude at 13.00 volts at the instant that the 10's counter starts its count cycle. This means that at the instant the unknown is at 13 volts a reference

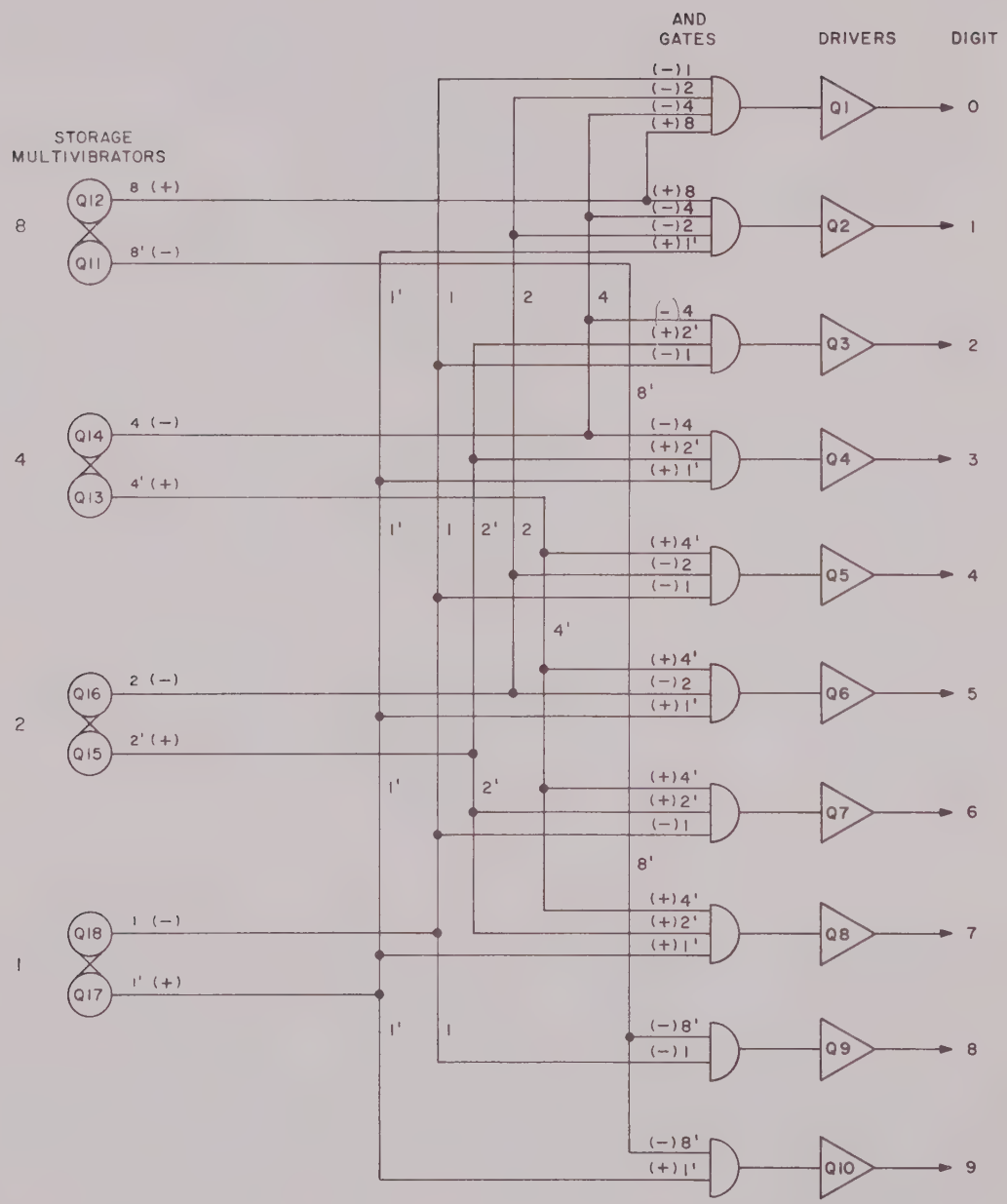


Figure 16. Typical 51.010-1 RSD Binary-to-Decimal Decoding, Simplified Logic Diagram

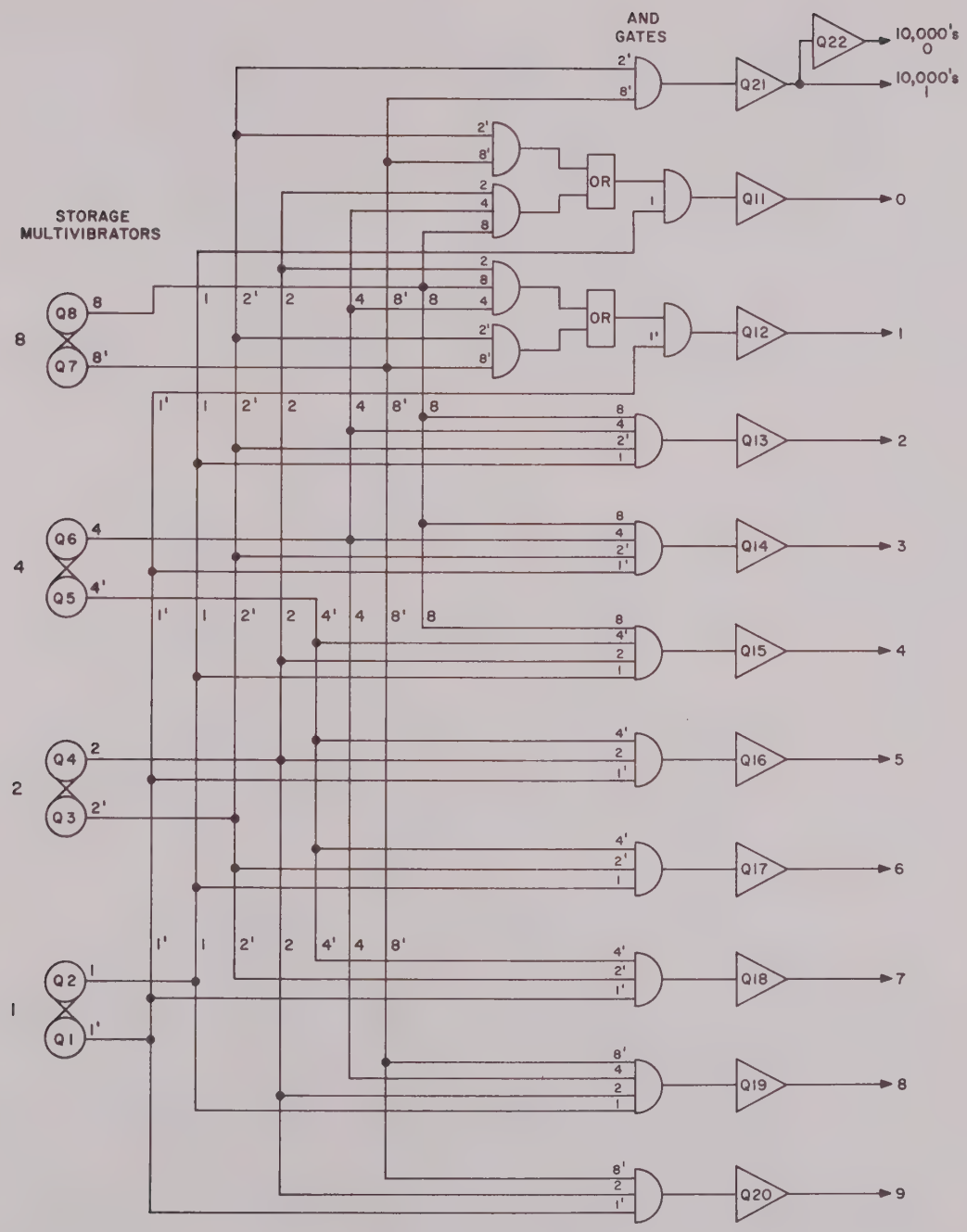


Figure 17. RSD 51.080-1 Binary-to-Decimal Decoding, Simplified Logic Diagram

current equal to 12.09 volts appears at the summing junction. The 1000's and 100's counters are locked and cannot increase their count; thus, even if the 10's counter counts to its maximum (9 count), the reference current (equal to 12.99 volts) is not sufficient to control the comparator summing junction and cause a *shift* pulse; thus the counters would stop cycling. To prevent this situation, two diodes (CR17 and CR18 in the 44.139-1 Units) are connected in parallel between the 1 and 8-count output leads of the BCD flip-flops and the base of Q12 of the corresponding 100's, 10's or 1's multivibrator. Thus as a counter reaches 9, it automatically shifts to the next counter due to a positive pulse through CR17 and CR18, and the sampling cycle is completed. A similar circuit is provided in the 1000's BCD (44.139-5 Unit) except the automatic shift (provided by CR17 and CR201) takes place on a 12 count. (It should be noted that the digital information obtained at the end of a sampling cycle will always represent the magnitude of the signal voltage at some point during the cycle, even though the input was changing rapidly.)

The following table briefly summarizes the TDVM operation as described in detail in the preceding paragraphs. The summary is given with respect to the time increments of Figure 10. (This table, as in the preceding text, assumes a +12.48 volt input.)

TIME	OPERATION
0	Sign Check Multivibrator triggered; sets decade counters to zero and checks relay K1 to ascertain that it is in the proper state. (In addition a small positive potential is applied to the comparator summing junction to prevent possible relay chatter on low-level input signals.)
1	Sign Check Multivibrator state reversed: 1000's multivibrator triggered, releasing 1000's counter; 100's,10's, and 1's counters 9-set. Reference current proportional to -09.99 volts applied to summing junction.
2	Reference current *smaller* than unknown: 1000's counter counts to one. Reference current now proportional to -19.99 volts.
3	Reference current *larger* than unknown: *shift* pulse reverses 1000's multivibrator (locking 1000's counter) which in turn triggers 100's multivibrator. 100's multivibrator in operating zero-sets 100's counter. Reference current now proportional to -10.99 volts.
4 through 19	During this time period the counting cycle continues through the 100's, 10's, and 1's counters until the reference current is proportional to -12.48 volts (equal in magnitude to the input unknown).
20	Reference and unknown *equal* in magnitude: *shift* pulse clamps units multivibrator which in turn triggers indicator clear multivibrator. Decade counter data transferred to storage cards for conversion and display.
21	Indicator clear multivibrator reversed: data clamped in storage circuits; pullover inverter cut off thus releasing sign check multivibrator. The next blocking oscillator pulse triggers sign check multivibrator and starts new sampling cycle.
22 (0)	Sign Check Multivibrator triggered; new sample operation started.

(4) *Automatic Range Selection.* The automatic range switching circuit performs two separate functions depending on the operating mode of the TDVM (automatic or manual range selection). In the automatic range selection mode (selected either locally or remotely) the circuit seeks and selects the lowest possible range capable of measuring a given input voltage (up to 20 per cent overload of a range). When a range is selected manually the circuit acts as an overload protection circuit to prevent damage of the precision input circuitry.

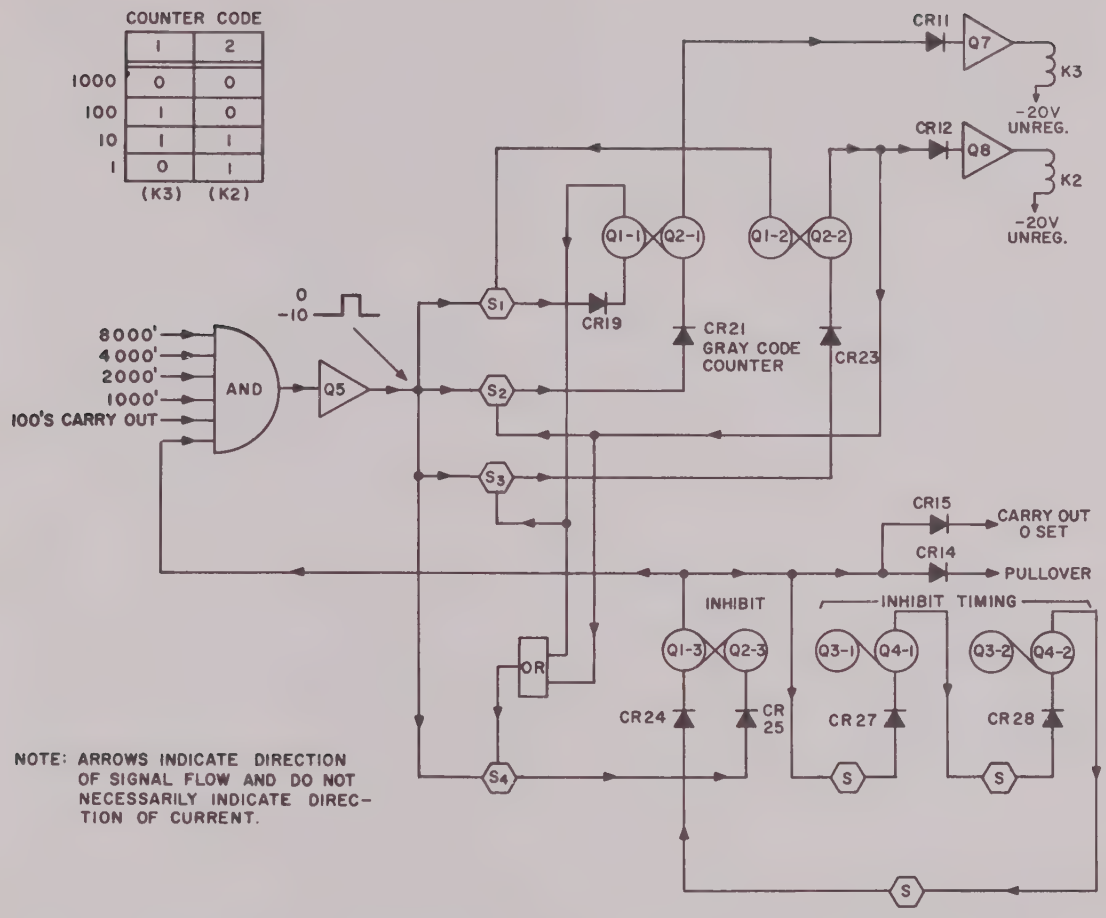


Figure 18. Down Range Circuit, Simplified Logic Diagram

This description assumes the instrument is in the automatic range selection mode; however, a description of circuit action when the instrument is in either the manual or remote modes is also given. The Automatic Range Switching Circuit 14.156 (Schematic D014 156 0S) essentially consists of two parts (down range and up range circuits); for clarity, these circuits are described separately.

Figure 18 is a simplified logic diagram of the down-range portion of the 14.156 Unit (portions of this circuit are common to the up-range circuit). The state of relays K2 and K3 determines the gain of the input dual DC amplifier circuit and thus the range of the TDVM. Figure 19a is a simplified schematic of the dual DC amplifier circuit showing relays K2 and K3. Figures 19b through e are simplified schematics showing the feedback circuit of the DC amplifiers in each of the four ranges as a resultant of the operation of the two relays.

Relays K2 and K3 (Figure 18) function in response to the gray-code counters consisting of multivibrator-1 (Q1-1 and Q2-1) and multivibrator-2 (Q1-2 and Q2-2). Multivibrator-1 controls relay K3 and multivibrator-2 controls relay K2; when either of the multivibrators is in the 1 state

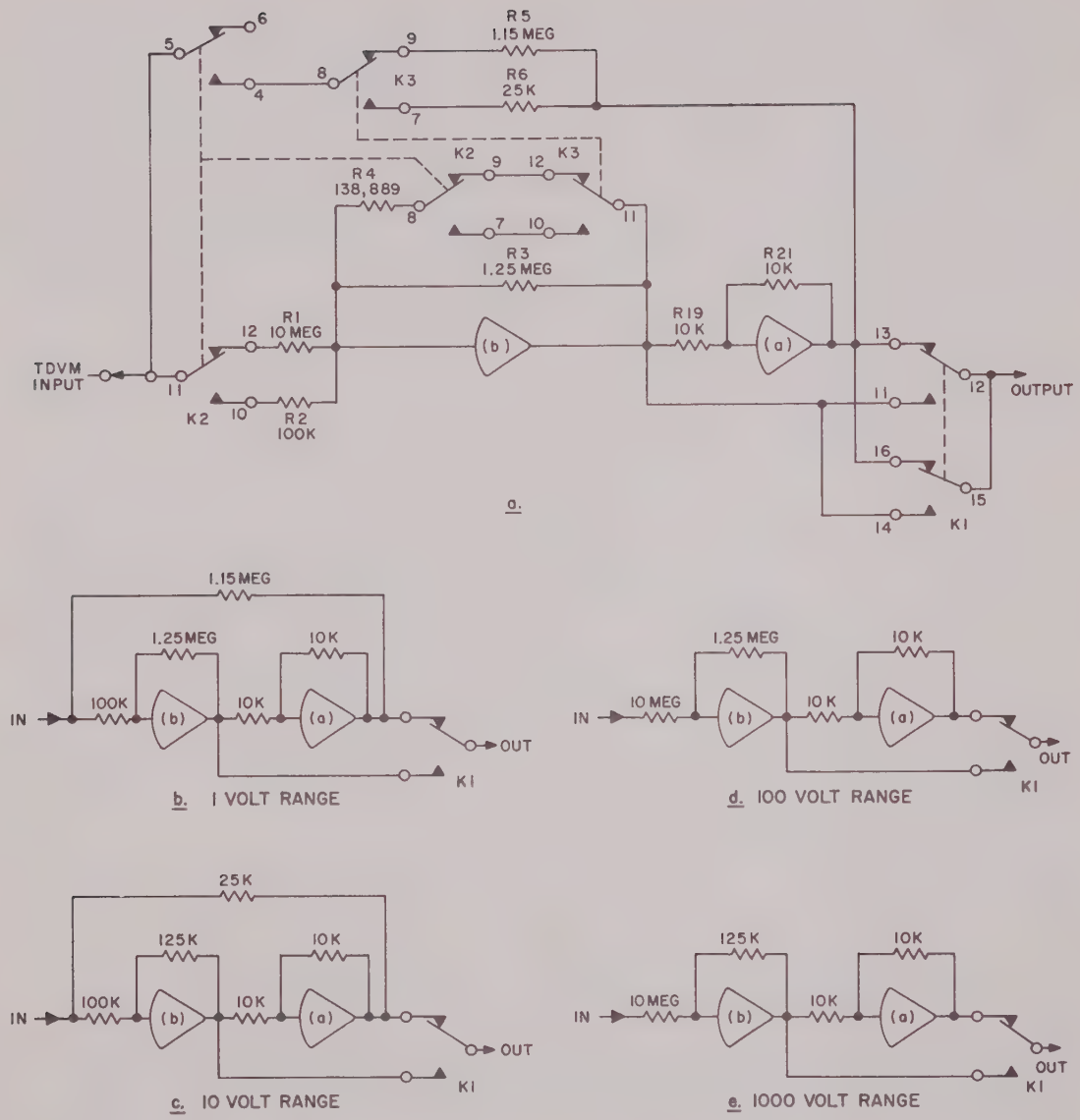


Figure 19. Dual DC Amplifier, Simplified Schematic Diagrams

(right-hand transistor cut-off, left-hand transistor conducting) its corresponding relay is energized. The table in Figure 18 lists the state of each multivibrator on the four ranges of the TDVM; the parenthetical notation under each column designates the relay controlled by that portion of the counter. To change ranges, therefore, it is necessary to change the status of the counter circuit. Note, however, that the TDVM will only down range one step at a time, i.e., if the proper scale is the 1 volt range and the instrument is on the 100 volt range, it will first step to the 10 volt range and then the 1 volt range.

The AND circuit on Figure 18 indicates if down ranging is required by sampling the output of the 1000's BCD counters and the 100's carry out voltage. If the 1', 2', 4' and 8' outputs are all negative this indicates a zero in the 1000's BCD. This information alone, however, is not sufficient since this condition also exists during the sign check cycle. Therefore an additional bit, the 100's carry out, indicates to the AND circuit that not only is the 1000's count zero but that the 100's counter has been released for counting and the 1000's zero is a result of magnitude evaluation, and not sign check. The zero in the 1000's counter at this time indicates the TDVM is on too high a range. The final input indicates to the AND circuit whether or not the TDVM is already in a range change cycle; this circuit is described later in the text.

Assuming that the 1000's counter is at zero, the 100's counter is open for counting, and the TDVM is not in the process of down ranging, the AND circuit (because of all negative inputs) saturates amplifier Q5. This generates a positive potential that is applied to the gated differentiators S_1 through S_4. The pulse from Q5 contains only the intelligence that the TDVM must be down-ranged; thus, by gating the differentiators as to which range the TDVM is on, the pulse is guided through the proper differentiators to down-range the TDVM to the next lower range.

Table VI lists by range the state of the collectors of each transistor in the counter, and the differentiators that are released.

TABLE VI. Differentiator Gating Sequence

Range	Gray Code		Multivibrator-1		Multivibrator-2		Released Differentiator
	Mult-1	Mult-2	Q1-1	Q2-1	Q1-2	Q2-2	
1000	0	0	-10	+2	-10	+2	S_2 & S_4
100	1	0	+2	-10	-10	+2	S_3 & S_4 (S_2)
10	1	1	+2	-10	+2	-10	S_1 & S_4 (S_3)
1	0	1	-10	+2	+2	-10	(S_1)

Comparing the table with Figure 18 the function of each gated differentiator may be derived as follows: a pulse through S_1 sets multivibrator-1 in the 0 state; a pulse through S_2 sets multivibrator-1 in the 1 state; a pulse through S_3 sets multivibrator-2 in the 1 state; and a pulse through S_4 triggers the inhibit multivibrator.

Under the released-differentiator column of the table (in the 100, 10, and 1 volt ranges) are differentiator designations in parentheses; these differentiators although released, do not function in the actual down-range operation. In being released however, they do prevent possible false triggering of one multivibrator (via transient pulses) when the other multivibrator is triggered.

As previously mentioned, a pulse through S_4 triggers the inhibit multivibrator (Q1-3 conducts, Q2-3 cut off). The collector voltage of Q1-3 (at +2 volts) performs four functions: (1) it locks the AND gate thus indicating a down-range step is in process (Q5 is cut off); (2) a positive level is sent out on the *carry out - zero set* lead resetting the BCD to zero and inhibiting the sign check FF thus preventing the start of a digitizing cycle during range switching; (3) a positive level is applied to the pullover line to prevent the indicator clear multivibrator from giving an indicator-clear signal; and (4) Q4-1 of the inhibit timing multivibrators is cut off.

The inhibit timing multivibrators (both are monostable) time the operation of the inhibit gate operation; due to the long duty cycle, two monostable multivibrators are used. When Q4-1 is cut off, approximately 50 milliseconds later it returns to its original state and triggers Q4-2. Again there is approximately a 50 millisecond delay and Q4-2 returns to its original state (con-

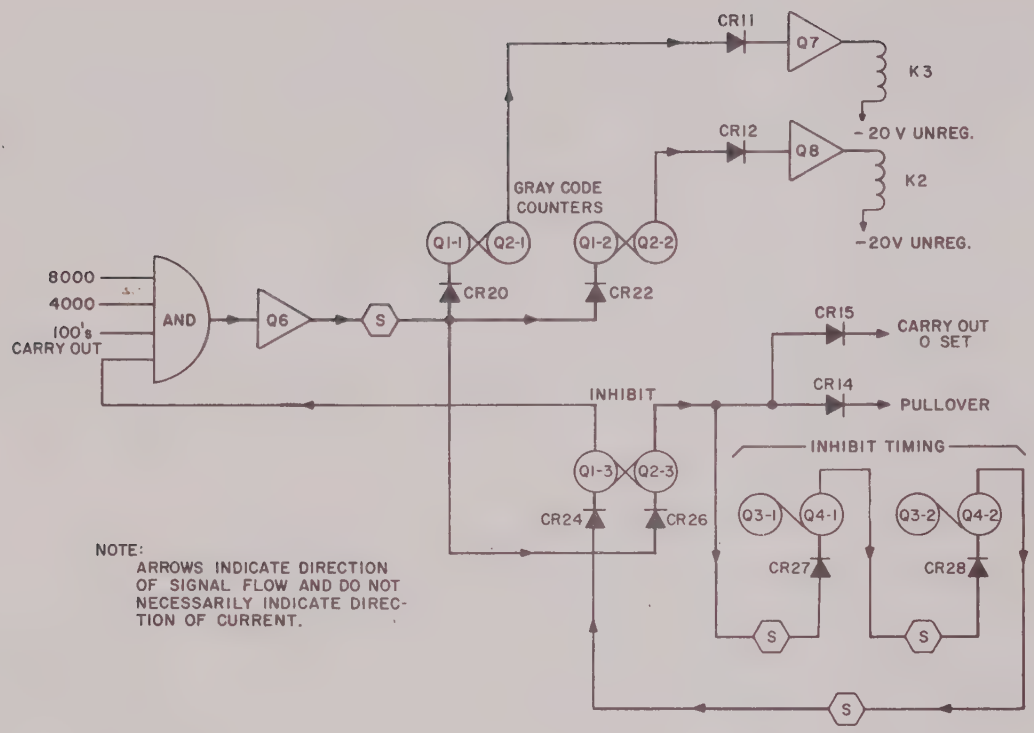


Figure 20. Up Range Circuit, Simplified Logic Diagram

ducting). Thus, after a delay of approximately 100 milliseconds, the positive collector potential of Q4-2 triggers the inhibit multivibrator by cutting off Q1-3. This removes the pullover voltage, the carry out 0-set signal and the positive potential from the AND gate lead. During the 100 millisecond delay, however, the TDVM gray-code counter has down ranged the instrument.

During the new conversion cycle, if the 1000's counter again registers a zero count the down-range procedure as described previously is repeated. Note that if the instrument is on the 1 volt range and a zero is read into the 1000's counter, that the only differentiator open is S_1; this has no effect since the multivibrator-1 is already in the 0 state. S_4 is not released so the inhibit gate is not triggered; the magnitude evaluation continues and the 1000's zero is displayed by the visual indicator.

When the instrument range is set manually, ground is removed from the emitter of Q5; thus, even though a pulse is passed by the AND gate, Q5 cannot conduct and down-ranging is not initiated.

Figure 20 is a simplified logic diagram of the up-range portion of the 14.156 Unit. The necessity of up-ranging is indicated when the 1000's BCD records a 12 count. (With the 20% over-range capability of the TDVM the last visual indication on the readout system is 11.999; thus, a 12 in the 1000's counter indicates an overload.) As previously mentioned when the 1000's BCD reaches a 12 count, diodes CR17 and CR201 (Schematic Diagram D026 158 0S, Sheet 3) automatically shift the count to the 100's counter. At this time an up-range is indicated via the AND gate (Figure 20) if Q1-3 of the inhibit gate does not indicate that up-range switching

action is already in process. From this point the action of the circuit is similar to that as described for the down range switching with the exception that the gray code counter is triggered to place the TDVM in the 1000 volt range. Thus despite what range the instrument is on, *the up-range circuit always sets the TDVM in the 1000 volt range,* and then, if necessary, the down range circuit seeks a lower range (if indicated by the input magnitude). For example, if the TDVM is on the 10 volt range and 100 volts is applied, the up-range circuit sets the instrument to the 1000's volt range and then the down range circuit will set the instrument in the 100 volt range. This feature assures a minimum duty cycle for the 100,000 ohm input resistor of the 1 and 10 volt range whenever an overload is indicated.

The functions of the inhibit multivibrator and the inhibit timing multivibrators are identical to those described in the down-range sequence. The major difference between the down-range circuit and the up-range circuit functions is that during manual range selection the up-range circuit is still active. Thus, the up-range circuit acts as an overload protection circuit for manual range selection.

The function of the overload circuit is primarily to protect the 100,000 ohm input resistor on the 1 and 10 volt ranges. The 10 megohm resistor of the 100 and 1000 volt ranges can handle up to 500 volts continuous overload (and higher potentials for a short duty cycle) when the instrument is in the 100 volt range. For these reasons the overload circuit controls only relay K2, de-energizing this relay when an overload is applied. The effect of controlling K2 is as follows: (1) if the TDVM is on the 100 volt range the instrument remains in this range but an overload lamp is lit; (2) if the TDVM is on the 10 volt range K2 is de-energized (TDVM reverts temporarily to the 100 volt range) and the overload lamp lights; (3) if the TDVM is on the 1 volt range K2 is de-energized (TDVM set temporarily to 1000 volt range) and the overload lamp lights. The TDVM remains in the temporary range for the 100 millisecond duty cycle of the inhibit multivibrator. As the inhibit multivibrator resets the TDVM will revert to the original manually selected range if the RANGE switch is not manually changed; however, after approximately 2 to 3 milliseconds the protection circuit will again place the instrument in the temporary higher range setting. The 2 to 3 millisecond overload when compared to the 100 millisecond period is sufficiently short for protection of the 100,000 ohm input resistor.

Figure 21 is a simplified diagram of the overload protection circuit. If an overload exists, thus triggering the inhibit multivibrator, Q9 is cut off (de-energizing K2, if energized) and Q10 conducts illuminating the overload lamp. The magnitude evaluation cycle is stopped (via CR14 and CR15) as previously described. The overload lamp shows up as a red spot on the left-hand side of the visual indicator thus signaling the operator to select a higher range*.

A 25 millisecond delay circuit is provided in the 12.687 Network in conjunction with the automatic range circuit (Drawing C012 687 0S). If there is a reversal of the input polarity, and the magnitude of the potential change is very large, the decay time of the DC amplifiers may be sufficient to cause the TDVM to down range prior to the amplifier output building up to the true magnitude of the new input. The instrument would then have to up range and re-seek the proper range setting. To prevent this a 25 millisecond monostable multivibrator (Q2 and Q3, Drawing C012 687 0S) is triggered every time the sign multivibrator in the programmer changes state. The positive collector potential of Q2 sets the gray code counter to the 1000 volt scale setting and holds it there for 25 milliseconds.

This delay gives the DC amplifier sufficient time to settle and then the range switching circuit is released (Q2 and Q3 re-set) and seeks the proper range. In addition, Q4 locks the indicator clear output so the readout cannot change and give an erroneous display. This feature prevents false outputs when the TDVM is feeding external equipment.

During AC operation of the 5002 or 5003, the TDVM is locked on the 10 volt range, and the TDVM or TDVOM ranging circuits are used to control the range relays in the AC-DC Converter. A ground from the converter is applied through P4-6 and diodes CR1 and CR2 to lock K2 and K3 on. [See Sheet 2 of Schematic D026 158 0S (for the 5002) or D026 212 0S (for the 5003).]

**The overload indicator also lights when the instrument automatically up or down ranges; it indicates that the TDVM is inhibited during the time range changing occurs.*

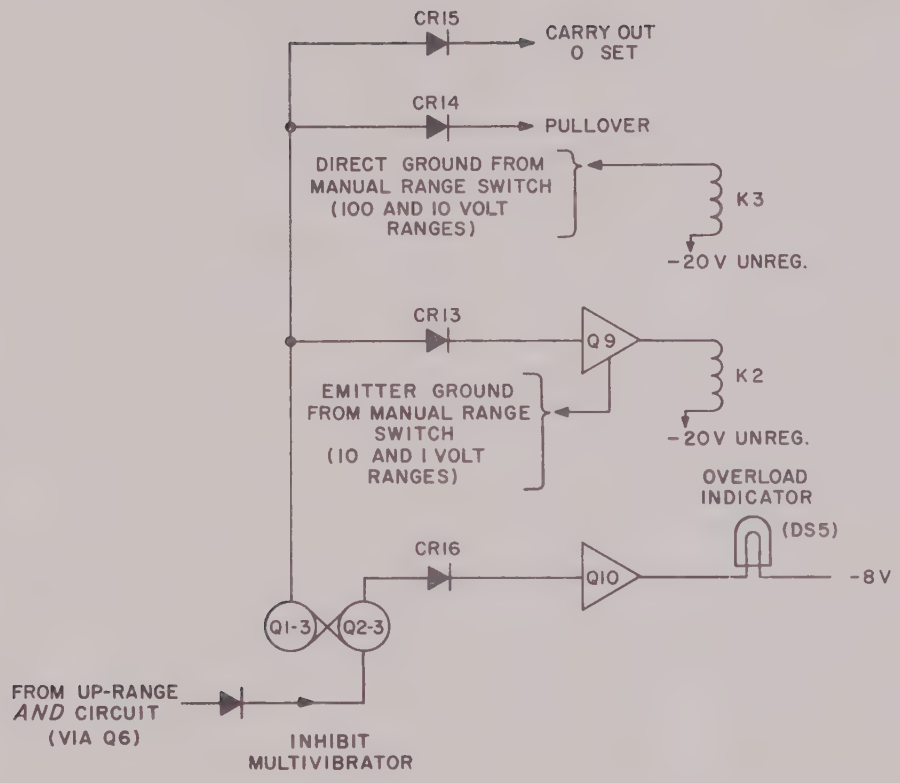


Figure 21. Manual Range Overload Protection Circuit, Simplified Logic Diagram

c. External Control Circuits

(1) *Remote Range Switching.* Connector P1 on the AC-DC Converter chassis provides connections for remote range switching. For remote range switching, both the A and B chassis RANGE switches must be in the REMOTE position. The instrument may then be programmed to any range by providing switch or contact closures to appropriate P1 terminations.

(2) *Single Cycle Command Circuit.* The operation of the TDVM in the previous description assumed the instrument was free running (FUNCTION switch in the INT position) and that the input was sampled at an average rate of 200 times per second. However, by placing the FUNCTION switch in the MAN position the TDVM will sample the input only when the TRIGGER switch on the front panel is depressed. The actual sample will be made at the normal TDVM sampling rate (5 millisecond average), but, the instrument will then stop and hold this readout until the TRIGGER switch is again depressed.

As shown on D026 158 0S, Sheet 2, depressing the TRIGGER switch applies +12 volts to Q13 of the single cycle multivibrator, cutting it off. This causes Q14 to conduct, cutting off Q10 (the pullover inverter) which permits the TDVM to take a normal sample. At the end of the sample, however, the carry-in signal from the units counter cuts off Q14 and the pullover inverter conducts thus preventing a new sample from being taken. Q14 remains in this state until the TRIGGER switch is again depressed. Note that when the FUNCTION switch is in the

INT position (free running) a continuous +12 volts is applied to Q13 preventing the single cycle multivibrator (Q13 and Q14) from affecting the sampling operation.

Placing the FUNCTION switch in the EXT position permits remote control of the single cycle command circuit. Any positive going pulse of approximately 10 volts amplitude and 4 microseconds rise time is sufficient to trigger the TDVM.

(3) *External Hold Circuit.* The sampling rate of the TDVM is faster than the operating capabilities of most accessory equipment used in conjunction with it. This is true in the case of the EAI high-speed printer; the printer cycles at a rate of 3 operations per second (compared to the average of 200 operations per second of the TDVM).

An external *hold* input (P1-68, Diagram D026 158 0S, Sheet 2) is provided for the TDVM to permit the external equipment to hold a TDVM reading.

A negative potential applied to P1-68 clamps the indicator-clear gate in the conducting state. This prevents clearing the storage circuits, thus holding the readout data until the negative potential is removed. The hold voltage *does not* stop the continuous sampling operation of the TDVM in any other respect.

The readout data (on plug P1) for external use is available in both binary-coded decimal or straight decimal form. Thus the TDVM readout capabilities can be used with a multitude of external accessory equipment and is an especially fast analog-to-digital converter.

d. Reference Circuits and Power Supplies

(1) *Reference Amplifier 6.464.* This unit consists of a stable voltage element and a chopper-stabilized DC amplifier; it functions as a -100 volt stable reference source. (See Drawing D026 158 0S, Sheet 1 for a simplified schematic diagram of this unit.)

The stable voltage source consists of a zener diode regulating network connected across the +40 volt supply. The diodes provide a stable potential of approximately 9.4 volts. This voltage is applied through R1 (NW6) to the input of the DC amplifier (AR2). The amplifier gain (determined by the ratio of the feedback to input resistance) is adjusted to yield a -100 volt output. The -100 volt regulated output is the reference source applied to the common side of the summing resistors in the 26.116 Network.

The reference amplifier (AR2) utilizes a conventional automatic balancing circuit consisting of a 60 cycle vibrator and a three-stage, high-gain, AC amplifier. Manual balance control is provided by R9 (Drawing D006 464 0S).

(2) *Power Distribution.* The 5002A Series TDVM operates directly from a commercial 117/230 volt, 50 or 60 cycle source.

Schematic Diagram D026 158 0S, Sheet 4 shows the input AC lines, the various rectifiers, and the associated regulator circuits (in block form). In addition, the distribution of the various DC and AC potentials is shown.

Detailed circuitry of all of the regulators (except Q1, Q2, and Q3 of the reference source) is shown on Schematic Diagram C043 094 0S. The reference regulator is shown in detail on Schematic Diagram D006 646 0S.

The power circuits of the TDVM supply the following DC voltages: -100 volts, -110 volts, ±20 volts, ±12 volts, -8 volts, +40 volts, and +2 volts. The power circuits also energize the cooling fan and supply 6.3 volts AC to the following circuits: the reference amplifier chopper, the dual DC amplifier chopper, and the heater elements of the oven on the Comparator and Diode Gate and the reference supply break-down (Zener) diode oven.

3. 5003A TDVOM

The operation of the digitizing circuits of the 5003A TDVOM is identical with that described for the 5002A TDVM. The 5003A differs from the 5002A mainly in the input circuits (dual DC amplifier networks) and therefore only these circuits of the 5003A are described in this section.

Figure 22 is a simplified schematic of the 5003A TDVOM input circuit. Comparing this drawing to Figure 19 illustrates the primary difference between the 5002A and 5003A. Two relays, K4 and K5, and two input resistors, R6 (10K) and R2 (1 megohm) are added to the 5003A input network. Since both of these relays are energized only when the unit is used to measure ohms, and the two input resistors are also used only for ohms measurments, the simplified schematics of Figure 19 are still applicable for the various voltage ranges. (The 100K resistor is designated R5 in the 5003A unit instead of R2 as shown in Figure 19.)

Figure 22 also contains a table which shows the relays in the K2 through K5 group that are energized on the various voltage and resistance ranges of the TDVOM. Note that K4 and K5 only energize when measuring ohms, and that K2 and K3 determine the meter range for both the ohms and voltage measurements. The automatic range circuit, which controls K2 and K3 in *either* the AUTO Ω or AUTO V configuration, functions as described in the 5002A Section and the description is not repeated here.

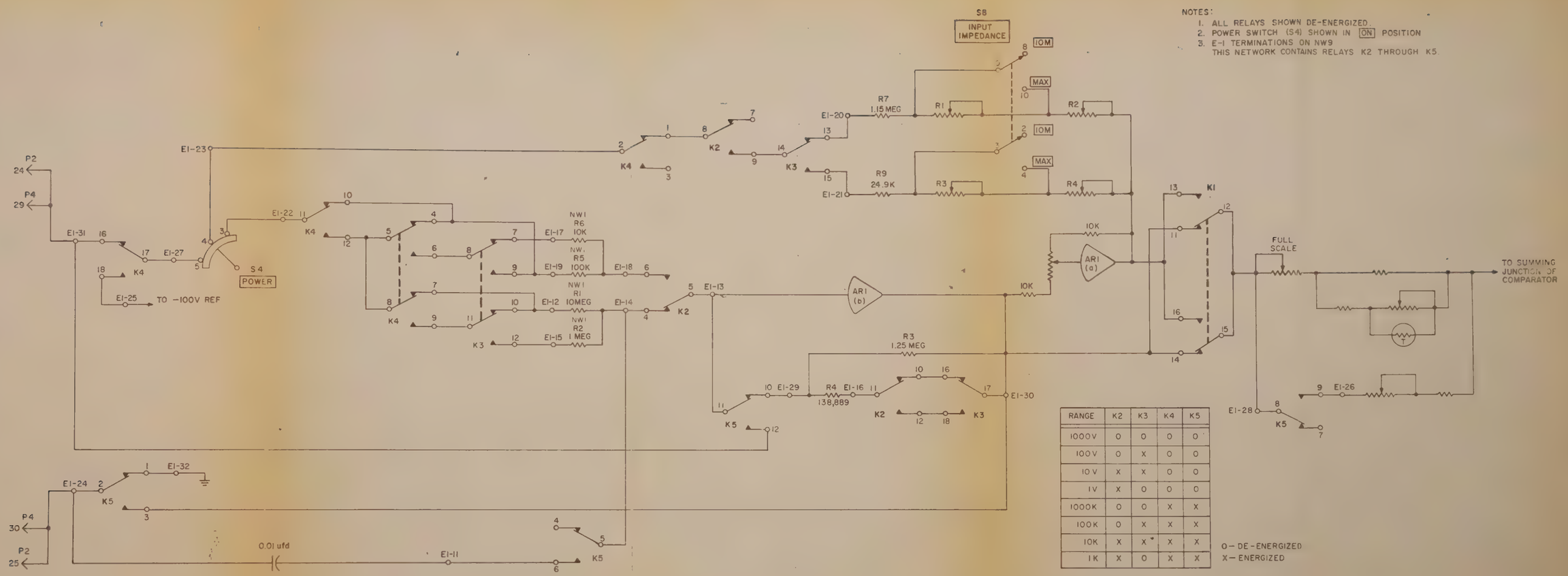
The primary function of K4 is to apply the -100 volts reference to the input of amplifier AR1-b. Relay K5 eliminates the internal feedback of AR1-b and connects the summing junction and output of the amplifier to J1-1 and J1-2 respectively. Thus, the unknown resistor becomes the feedback resistor of AR1-b. Figure 23 shows simplified schematics of the input amplifier circuit for each of the four ohm ranges. Note that since the -100 volt reference is applied to AR1-b the output of this amplifier is always positive when an unknown resistor is connected between J1-1 and J1-2. Amplifier AR1-a therefore is not used in the ohms configuration since AR1-b always supplies the proper polarity output.

The output voltage of AR1-b is in proportion to the magnitude of the unknown resistor. In an operational amplifier the summing junction is held at virtual ground; thus, the current through the input resistor (R1, R2, R5, or R6) is a fixed value depending on the meter range. The current through the unknown resistor must be of equal magnitude to this input current for the summing junction to be at virtual ground. The output voltage of AR1-b must be of a value sufficient to cause this required feedback current. Because the feedback current is fixed, by Ohm's Law the output voltage of AR1-b is directly proportional to the value of the unknown resistor. Also, since the fixed current is a multiple of the power of 10 the output voltage of AR1-b when digitized is the numerical equivalent of the unknown resistor value. By properly placing the decimal and displaying the numerical value of the voltage, as is done in the 5003A, the magnitude of the unknown resistor is shown.

The digitizing of the AR1-b output is accomplished in the same manner as described for the 5002A TDVM.

4. AC-DC CONVERTER

The AC-DC Converter, Model 49.038, accepts AC input signals ranging from 0 to 1200 volts (in four ranges) and produces a positive DC output proportional to the RMS value of the input signal. The DC output is in a range of 0 to 12.00 volts and is in direct proportion to the selected conversion range; i.e., 100 volts RMS input on the 100 volt range produces a 10 volt DC output; however, on the 1000 volt range the 100 volt RMS produces an output of 1 volt DC.



RANGE	K2	K3	K4	K5
1000V	0	0	0	0
100V	0	X	0	0
10V	X	X	0	0
1V	X	0	0	0
1000K	0	0	X	X
100K	0	X	X	X
10K	X	X	X	X
1K	X	0	X	X

0 – DE-ENERGIZED
X – ENERGIZED

FIGURE 22
5003A TDVOM INPUT CIRCUIT,
SIMPLIFIED SCHEMATIC DIAGRAM

The AC input signal is applied to amplifier 1B through the 1 megohm precision input resistor. The gain of amplifier 1B is set for each range by changing the feedback resistance. In the 1 volt range the feedback resistance is approximately 1 megohm and amplifier gain is approximately one. The output of amplifier 1B is applied to amplifier 1A through the range switch network. On the 1 volt range the input resistance is 25 kilohms and the gain is one. Diodes CR1 through CR3 clamp the output of amplifier 1A at 0 volts during the negative half of its input cycle.

The output of amplifier 1A is summed in amplifier 2B with the output of amplifier 1B. The input resistors are scaled to produce a gain of ten for the 1A input, and a gain of five for the 1B input. The 1.414 volt positive peaks are multiplied by ten and summed with the 1.414 volt sine wave which is multiplied by five and is 180 degrees out of phase. The resultant output, disregarding filtering, is similar to the output of a full-wave rectifier.

The filtered output of amplifier 2B is applied to amplifier 2A. The gain of amplifier 2A is set to 2.2508 in order to produce the desired output.

b. Automatic Range Switching

In the AUTO AC mode, the TDVM or TDVOM is locked on the 10 volt range. The ranging circuits in the TDVM or TDVOM check the input from the AC-DC Converter and control range switching relays K1 and K2 in the converter. Table VII shows the K1-K2 configuration for each range. Note that K1 and K2 in the AC-DC Converter correspond to K2 and K3 in the TDVM or TDVOM as listed on the table associated with Figure 18.

TABLE VII. AC-DC Converter Range Data

Range	K2	K1
1000 VAC	OFF	OFF
100 VAC	ON	OFF
10 VAC	ON	ON
1 VAC	OFF	ON

Sheet 2 of Schematic D049 038 0S shows the relay switching circuits which determine the mode of operation in the AC-DC Converter. The second deck of the MODE switch energizes K3, K4, and K5 in the AC AUTO mode. In the REMOTE mode a ground must be supplied to P1-24 to energize K3, K4, and K5.

The various contacts on these three relays apply the input to the AC-DC Converter, light the AC indicator lamp, light the appropriate decimal point location lamp, and lock the sign relay. A ground potential is applied to P1-36 to lock the TDVM or TDVOM in the 10 volt range.

CHAPTER V

MAINTENANCE

1. INTRODUCTION

This section contains instructions on trouble analysis and transistor servicing techniques to aid the maintenance technician. Also included in this manual are replaceable parts lists (Appendix I) and schematic and wiring diagrams (Volume II). A component location diagram is included with each schematic to facilitate locating a particular component on an etched-circuit board.

2. TROUBLE ANALYSIS

This section lists some general troubleshooting techniques for the 5002 and 5003. The section is divided into the three major areas: the basic 5002A TDVM, the ohms circuit which is added to produce the 5003A TDVOM, and the AC-DC Converter. If a malfunction is detected, use the applicable procedures in the order given.

a. 5002A TDVM

To assist in analyzing a malfunction, each circuit of the TDVM should be considered as being in one of three main groups: the input amplifiers and associated circuits, the closed-loop logic circuits (including the indicator bank), and the power and reference supplies and regulators.

Trouble analysis is best accomplished by observing the action of the indicators and relating this action to possible causes of trouble. Accordingly, the suggested troubleshooting procedures in the following paragraphs are grouped as to indicator display.

(1) *Indicators Displaying Fixed Reading.* If a fixed reading is displayed regardless of the input, the most likely source of trouble is the logic circuitry. The following steps outline one suggested method of locating a malfunction of this type.

(a) Check the Programmer for the presence of either count or shift pulses at pin P (shift) or S (count) of connector A6-J1.

(b) If one or the other is not present, check for blocking-oscillator output pulses. The output frequency may be checked by using a calibrated time-base oscilloscope, and should be between 5 and 9 KC. If the blocking oscillator is functioning correctly, check the double AND gate consisting of Q1, Q2, and Q3 on the Programmer.

(c) If count or shift pulses are present, check the Q11-Q12 multivibrator on each of the BCD counters. (See Timing Diagram, Figure 10.) If necessary, replace each BCD card in turn with a spare card known to be operational. (Interchanging the existing cards in the TDVM will not accomplish the desired check, since all four cards are in a closed loop.)

(2) *Indicators Displaying All Zeros.* An all-zero display regardless of the input generally indicates a malfunction in the input amplifiers or the comparator and associated circuits. Check as follows:

(a) Apply a positive input to the TDVM and monitor the output of each DC amplifier at the TEST POINT connector. The first amplifier (AR1-b) output is at terminal 8, and the second amplifier (AR1-a) output appears on terminal 9.

(b) If the amplifiers are functioning normally, remove the Summing Resistor Network (NW-2) and check for positive voltage at pin 12 of relay K1. If a negative voltage appears at this point, check the relay, and the following Programmer circuits: Sign Check Multivibrator (Q11-Q12), Sign Multivibrator (A6-Q7), and the Relay Amplifier (Q5).

(c) If the voltage at K1-12 is normal (positive), change the polarity of the TDVM input signal, and again check for positive voltage K1-12. If this point is now negative check all circuits listed in Sub-Paragraph *(b)*.

(d) If the voltage at K1-12 remains positive after changing the input polarity, proceed to the comparator. Under the present conditions the Comp Out - line should be -10 volts, and the Comp Out + line close to zero.

(e) If all of the previously listed circuits appear to be functioning normally, the trouble may be in one of the BCD Counter cards. This can be verified by replacing each card in turn with a card known to be operational.

(3) *Indicators Display Continually-Changing Random Digits.* A display of this type usually indicates that the logic circuitry is functioning properly but that trouble exists in the input circuits. Proceed as follows:

(a) Remove relay K1 and attempt to zero-set the instrument.

(b) If zero-setting can be accomplished, the input amplifiers and associated circuitry should be checked.

(4) *Two Digit-Display on One Indicator.* If one of the indicators displays two digits simultaneously, the usual cause is diode leakage in the BCD-to-decimal converter section of a Readout Storage Decade. This is verified by the appearance of certain combinations of digits such as 8 and 9, 3, and 5, etc.

NOTE

Noise on the input signal may also cause one or more of the indicators to flicker between digits.

(5) *Blurred Readout Display Digit.* Should a particular digit of a display window appear blurred (or fuzzy) the cause is usually due to the filament of the lamp, which illuminates the digit, being off center. This condition can normally be corrected by removing the particular lamp, rotating it 180°, and re-inserting in the socket; in some instances the bulb may have to be replaced.

b. Ohms Circuit (5003 Only)

If a 5003 operates correctly on DC scales, but malfunctions on ohms, check K4 and K5. If the relays are operating normally, check R2 and R6 on NW1 (although this unit is sealed, resistance checks may be made at the input pins. Relays K2 and K3 effectively isolate these two resistors.)

c. AC-DC Converter

If a malfunction exists only during AC operation, use the following procedures to locate the faulty etched-circuit card.

(1) *DC Gain Check.* A simple DC gain measurement rapidly checks the accuracy of the converter. The accuracy of this check, however, is dependent on the accuracy of the DC voltage source. Since the converter is calibrated to produce a DC output proportional to the RMS value of the AC input, the output of the converter for a square wave or DC input equals the input multiplied by the factor $\frac{\pi}{2\sqrt{2}}$. Also, because each range is scaled to produce an output between 0 and +10 volts, the input must be multiplied by a suitable scaling constant. Table VIII lists the various multiplication factors for each range.

By applying a positive DC input, operation of the entire converter is checked. Should an error exist, apply a negative input. This effectively removes amplifier 1A from the circuit (by the clamping action of CR1 and CR3). Elimination of the error indicates that amplifier 1A is defective.

If a low frequency square wave of equal positive and negative peaks is applied to the converter, and the output is monitored with an oscilloscope, inaccuracies in amplifier 1A may readily be detected. If the magnitude of the DC waveform varies at the frequency of the input, a malfunction in amplifier 1A is indicated.

TABLE VIII. Range DC Multiplication Factors

Range	Scale Constant	Range Multiplication Factors
1 volt	10	$\frac{\pi}{2\sqrt{2}}(10) = 11.107$
10 volts	1	$\frac{\pi}{2\sqrt{2}}(1) = 1.1107$
100 volts	$\frac{1}{10}$	$\frac{\pi}{2\sqrt{2}}(.1) = .11107$
1000 volts	$\frac{1}{100}$	$\frac{\pi}{2\sqrt{2}}(.01) = .011107$

3. VOLTAGE CHECKS

Table IX lists various check points in the converter and the voltage that should be present at each point. The potentials as listed are measured with respect to chassis ground with the unit on the 1 volt range and a 1 volt RMS AC signal applied to the input.

Trouble in the amplifier circuits may often be isolated to a specific amplifier by checking the balance adjustments. Inability to balance an amplifier indicates that the unit is faulty.

Interchanging of similar printed circuit cards with another unit will often isolate faulty circuits.

TABLE IX. Converter Voltage Check Points

Circuit	Check Point	AC Voltage (Volts)	DC Voltage (Volts)
1. Power Supply Regulator	P1-53 P1-30 P1-29 P1-28		-24V (Unreg.) +30 +15 -15
2. Output of amplifier 1B	NW3-J1-8	See Figure 24	See Figure 24
3. Output of amplifier 1A	NW1-J1-2	See Figure 24	See Figure 24
4. Output of amplifier 2B	NW2-J1-2	See Figure 24	See Figure 24
5. Output of amplifier 2A	P1-75		+10

4. TRANSISTOR SERVICING TECHNIQUES

Although servicing and troubleshooting procedures applicable to transistor circuits are similar in many ways to the techniques used with vacuum tube circuits, certain differences exist, and several extra precautions are necessary when servicing transistor circuits. The following suggestions and techniques are given to aid maintenance personnel who are not familiar with servicing transistorized equipment.

a. Etched Circuit Board Soldering

The techniques and precautions employed while soldering any electronic equipment still apply, but there are several additional factors to be considered when working with etched circuit board.

Wire leads or components fastened to the board by their leads may be replaced using the following procedure:

(1) Grip the lead to be removed with a pair of long-nose pliers, (in cases where this is impossible due to extremely short or hidden leads, the component itself must be carefully grasped). While applying pressure to the lead, touch a well-tinned, small (40 watt or less), soldering iron to the fillet. If the lead does not slip out immediately, remove the soldering iron and recheck to be sure the correct fillet is being heated.

(2) Clear the excess solder from the hole by touching the iron to it briefly and either blowing the excess solder out or carefully pushing it out with a soldering aid (GC Electronics Number 9093 or equivalent).

(3) Bend the leads on the new component or jumper to fit the board connections. Insert the component, but *do not* cut the leads.

(4) With the component or jumper held in place, touch the soldering iron to the lead and allow solder to run down the lead and form a fillet. Heat should be applied to the lead only until the fillet has formed. It is not necessary to fill the hole with solder, and some components such as transistors and diodes may be damaged by prolonged application of the soldering iron.

(5) After both leads have been soldered, use a pair of diagonal cutters to cut the lead off as close to the board as possible. Use the soldering aid to carefully scrape any excess flux or solder off the board.

Replacing components such as transistors, relay and chopper sockets, potentiometers, or networks with multiple connections is accomplished in essentially the same manner. Removal of these components is much easier if special tips such as the Ungar Electric Tools Number 856 (5/8" diameter cup) and Number 858 (bar) are used. These tips are used for component *removal* only, and permit all leads to be freed simultaneously.

If the above procedures are strictly adhered to, no trouble with the etched conductor itself should be encountered. If, however, a conductor becomes cracked or broken it may be repaired by carefully soldering a tinned piece of bus wire over it. Again extreme care should be taken not to overheat the strip and cause it to separate from the board.

b. Transistor Servicing

Most transistors are mechanically rugged, but they are easily damaged by excessive heat. If it becomes necessary to solder near a socket-mounted transistor, the transistor should be removed to prevent damaging it. When the transistor is soldered to the board, extreme care should be taken to prevent damage to it from overheating. Always use a small, well-tinned soldering iron and work as quickly as possible.

Transistors and small diodes which are soldered directly to the board should be removed only when there is strong reason to believe they are defective, as they are often over-heated while being removed. When soldering transistors or diodes a heat sink should be used, whenever practicable, on each lead as it is soldered. Two common methods of protecting these semi-conductors from overheating while soldering are holding the lead with a pair of long-nose pliers; or clipping an alligator clip, the jaws of which have been filled with solder, on the lead.

Power transistors, which are usually used in power amplifiers and power supplies, are mounted on metal chassis plates which function as heat sinks to dissipate the heat generated during normal operation. The metal case of a power transistor is usually the collector and operates at relatively high potentials. For this reason power transistors must be mounted so that they are electrically insulated from the heat sink. At the same time, heat from the transistor must be transferred easily to the heat sink. A common method of accomplishing this is by using a mica, anodized aluminum, or fiber glass washer coated with silicone grease. The washer provides electrical insulation, and the silicone grease increases the heat conduction. When replacing a power transistor, use only a single washer, and coat both sides with silicone grease (Dow Corning Number 4 Compound or equivalent). As a final precaution before applying power to the unit, check the resistance between the body of the transistor and the heat sink to ensure that no short or high resistance leakage path exists between these points.

Diodes, electrolytic capacitors, and the transistors themselves used in transistor circuits are easily damaged by voltage overload. For this reason transistors should never be removed or inserted with power applied, and special care must be taken in the selection and use of test equipment. Signal generators commonly used in servicing vacuum tube circuits are often capable of producing enough output to overload and permanently damage the diodes, electrolytic capacitors, and transistors used in transistor circuits. Always start with the minimum output signal and slowly increase it to the desired level.

The meter used for continuity and resistance checks must be carefully chosen. Some ohmmeters use batteries with a higher voltage rating than the transistors and capacitors being checked, and will destroy them. For this reason a meter with a 1-1/2 volt battery (Triplett Model 630A or equivalent) is recommended. In order to prevent damage to the small electrolytic capacitors used in these circuits it is essential to determine the polarity of the ohmmeter leads. This may be done easily by using another meter set to a low DC scale.

c. Transistor Troubleshooting

As with any other type of electronic circuit, the first step in troubleshooting transistor circuits is a visual inspection for charred, discolored, or leaky components; broken, shorted, or loose connections; heavily tarnished or broken connectors; and physical damage to the board itself. The next step is to replace any relays, ovens, or choppers, which are socket mounted on the board, with units known to be good. This is done not only because it is fairly easy, but also because each contains mechanical moving parts which may fail due to normal wear. If the trouble is not located by either of these steps, the board may be dynamically tested by applying all supply voltages and a signal input and then checking voltages and signals on the board until the trouble is isolated. If dynamic testing is impossible due to the lack of suitable test equipment, or availability of "down time" on the equipment in which it is used, the trouble can usually be located through resistance and continuity checks.

Refer to the schematic when making resistance checks to be sure that meter polarity is correct for any electrolytic capacitors in the circuit and that parallel DC paths are not affecting the readings. When the board is removed many components are naturally isolated by the plug or pin connections. Others are effectively isolated by capacitors in series with them. When it becomes necessary to unsolder and lift one end of a component from the board to isolate it for resistance checks, resistors should be chosen whenever possible as they are the component least likely to be damaged by the heat. In many cases, by carefully selecting the correct lead to disconnect, several components may be isolated at one time. It is not usually necessary to risk overheating a transistor by unsoldering it to make resistance checks. For example, lifting one end of the collector load resistor and one end of the emitter resistor would effectively isolate the transistor in a normal transistor amplifier stage.

Once a transistor is isolated, it may be checked using the following procedure:

(1) Set the ohmmeter to a high range and connect it between the base and the collector leads; reverse the leads and note which connection caused the higher reading. This is the reverse-bias direction.

(2) Connect the ohmmeter to reverse-bias the transistor and note the reading. Short the base to the emitter. The reading should decrease. Remove the short.

(3) Move the lead on the base to the emitter and note the reading. Reconnect the short. The reading should increase.

This test will indicate a burnt-out transistor but not a weak or high-leakage transistor. If the transistor is still suspected, and no other troubles are found, substitute one known to be good.

CHAPTER VI

CALIBRATION

1. INTRODUCTION

This chapter contains instructions and procedures for complete calibration of the 5002 or 5003. As previously indicated, each instrument is completely calibrated prior to shipment and should not require any adjustments upon receipt. If, however, it later becomes necessary to replace any components which affect the accuracy or calibration of the instrument, re-calibration is necessary.

Calibration of an instrument with the accuracy of the 5002 or 5003 is an exacting procedure requiring precision equipment and extremely stable voltage sources not normally available in field installations. Unless such equipment is available, EAI recommends that the instrument be returned to the factory if re-calibration becomes necessary.

The following procedures are divided into three areas: the basic 5002A TDVM, the ohms section (5003A TDVOM) and the AC-DC Converter. Note that the TDVM or TDVOM is used during the AC-DC Converter calibration procedure so the procedures should be done in the order listed.

2. 5002A TDVM

a. Required Equipment

The equipment listed in the following table is required for a complete re-calibration of the 5002A TDVM.

TABLE X. 5002A Calibration, Required Test Equipment

Component	Recommended Type	Used For
Precision Voltage Divider (100,000 ohms)	Leeds and Northrup, Model 4395 (or equal)	DC Gain Adjustment Summing Network Trimming Adjustments Reference Adjustment
Galvanometer	Leeds and Northrup, Catalog Number 2430D (or equal)	DC Gain Adjustment Summing Network Trimming Adjustments Reference Adj.
Microammeter	Hewlett-Packard, Model 425A (or equal)	TDVM Unloading Adjustment
Secondary Standard Voltage Cell (Calibrated to .005%)	Epley Number 103 (or equal)	Reference Adjustment
Stable DC Source (about 100 volts)		DC Gain Adjustment
30,000 Ohms Ten-Turn Potentiometer	Helipot, Model 30,000-A1 (or equal)	Summing Network Trimming Adjustments

b. Preliminary Procedures

Before proceeding with the calibration procedure outlined in Paragraph *c.*, the preliminary checks and adjustments in this paragraph should be performed. This will ensure that the TDVM is functioning normally with all amplifiers balanced and power supply outputs at the correct levels.

Proceed as follows:

(1) Remove the TDVM from the rack or dust cover. Add the following two jumpers to P4: P4-16 to P4-20 and P4-15 to P4-20. Apply line voltage through an auto-transformer, so that the applied primary voltage may be varied, as follows: hot lead to P4-41, common to P4-42, and chassis ground to P4-43.

(2) Set the input to 117 volts AC and permit the TDVM to warm-up for two hours with the power control switch in STANDBY.

(3) Using a VTVM (accurate to ±1%) check (and adjust if necessary) the following DC operational voltages: ±40V, ±20V, ±12V, -8V, +2V, and -110V. All voltages except the +40, ±20 and -110 volt outputs should be within 10% of the rated level with the line voltage first set at 105 volts and then at 125 volts. The +40 and ±20 volt and -110V levels should be within 1% of the rated value. Reset the line level to 117 volts.

(4) Balance each of the DC amplifiers as outlined in Paragraph 2*b.* through 2*e.*, Chapter III. Balance the reference amplifier in the same manner, connecting the meter between pins 1 and 16 of the TEST POINT connector (P2) and adjusting R9 on the Reference Amplifier card.

(5) Using a calibrated time base oscilloscope, check the frequency of the Programmer blocking oscillator. The correct value is between 5 and 9 KC.

This completes the pre-calibration checks and adjustments; the instrument is now ready for the calibration procedure described in the following paragraphs.

c. Calibration Procedure

The adjustments listed in this paragraph should be made in the order given.

(1) *Reference Amplifier Adjustment.* Set up the test circuit as illustrated in Figure 25. (The setting of the L & N divider is determined by the actual potential of the standard cell.)

Adjust R12 on the Reference Amplifier 6.464 until a null is obtained on the galvanometer. This adjustment sets the reference at -100 volts. (For the physical location of R12 see the Reference Amplifier 6.464 component location diagram.)

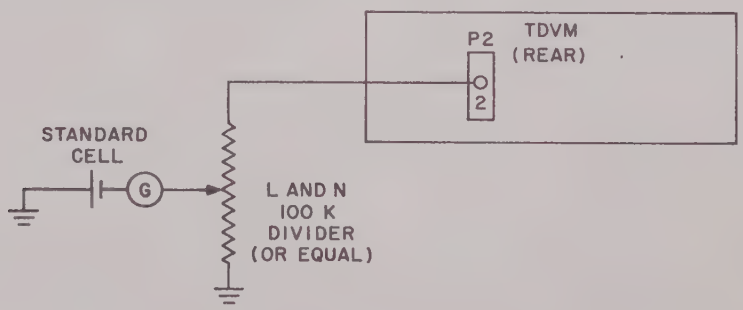


Figure 25. Reference Adjustment, Test Setup

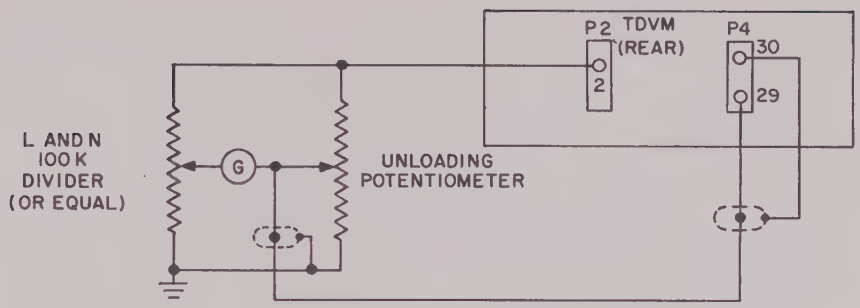


Figure 26. Full Scale and Trim Pot Adjustment, Test Setup

(2) *Full Scale Adjustment*

(a) Set up test circuit as shown in Figure 26.

(b) Reset ZERO adjustment.

(c) Set the TDVM range switch to the 100 volt position (manual range setting).

(d) Set the L & N Divider for -7.775 volts; adjust the test circuit unloading potentiometer for a galvanometer null.

(e) Adjust the FULL SCALE ADJ potentiometer (R14) on the 12.687 Network Card for a displayed reading of -7.775 volts.

NOTE

The display should remain constant over a wide range of the FULL SCALE ADJ potentiometer. Set the potentiometer in the center of this range.

(f) Switch the TDVM to STANDBY and re-check the Zero adjustment.

(3) *Summing Resistor Trim Pot Adjustment.* Use the test set up shown in Figure 26. These adjustments should not be attempted until the ZERO adjustment (Paragraph (2), Step *(f)*) check is made. Re-check the ZERO adjustment (in the STANDBY mode) after each of the procedural steps outlined in this paragraph. Each of the following steps should be performed with the TDVM set on the 100 volt range.

The trim pot physical locations are shown on the Summing Resistor Network 26.116 component location diagram.

(a) 8000 Trim Pot Adjustment

(1) Apply an input of -80.015 volts to the TDVM.

(2) Adjust R9p (NW2) until the TDVM readout flickers between -80.01 and 80.02*.

(3) Set the TDVM to STANDBY and re-check the ZERO setting.

**Approach the settings from the high side, i.e., 80.03, 80.02, and then to the flickering state.*

(b) 4000 Trim Pot Adjustment

(1) Apply an input of -40.015 volts to the TDVM.

(2) Adjust R11p (NW2) until the TDVM readout flickers between -40.01 and 40.02.

(3) Set the TDVM to STANDBY and re-check the ZERO setting.

(c) 2000 Trim Pot Adjustment

(1) Apply an input of -20.015 volts to the TDVM.

(2) Adjust R13p (NW2) until the TDVM readout flickers between -20.01 and -20.02.

(3) Set the TDVM to STANDBY and re-check the ZERO setting.

(d) 1000 Trim Pot Adjustment

(1) Apply an input of -10.015 volts to the TDVM.

(2) Adjust R15p (NW2) until the TDVM readout flickers between -10.01 and -10.02.

(3) Set the TDVM to STANDBY and re-check the ZERO setting.

(e) 800 Trim Pot Adjustment

(1) Apply an input of -8.015 volts to the TDVM.

(2) Adjust R10p (NW2) until the TDVM readout flickers between -8.01 and -8.02.

(3) Set the TDVM to STANDBY and re-check the ZERO setting.

(4) Apply an input of -87.77 volts and check the FULL SCALE ADJ setting. If this adjustment requires resetting, repeat Steps *(a)* through *(e)*.

(4) *DC Gain Adjustment*

(a) Set up the test circuit as shown in Figure 27.

(b) Set the TDVM to the 10 volt scale.

(c) Apply a negative potential of approximately -10 volts to the TDVM input; record the reading.

(d) Apply a positive potential *equal in magnitude* to the potential used in Step *(c)* to the TDVM input.

(e) Adjust R20 (NW7) for a readout equal to the recorded value in Step *(c)*.

(f) Repeat Steps *(c)* through *(e)*.

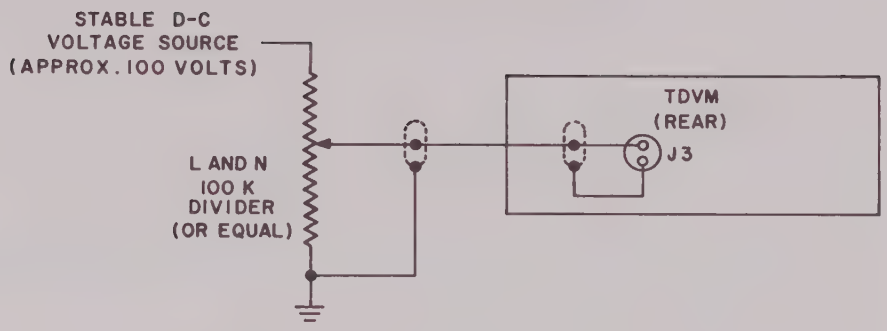


Figure 27. DC Gain Adjustment, Test Setup

(5) *TDVM Unloading*

(a) Set up the test circuit illustrated in Figure 28. (The switch by-passing the meter permits setting the L & N Divider without subjecting the meter to excessive current flow.)

(b) Set the TDVM to the 10 volt range and apply an input of -10.00 volts.

(c) Set the INPUT IMPEDANCE switch to MAX and open the meter bypass switch.

(d) Adjust R4 (NW7) for minimum current through the microammeter (maximum allowable reading of 0.02 microamperes). This sets the input impedance to 500 megohms or greater. (Be sure the current measured on the microammeter is from the source voltage. Improper adjustment can cause the input amplifier circuit to appear as a negative impedance.)

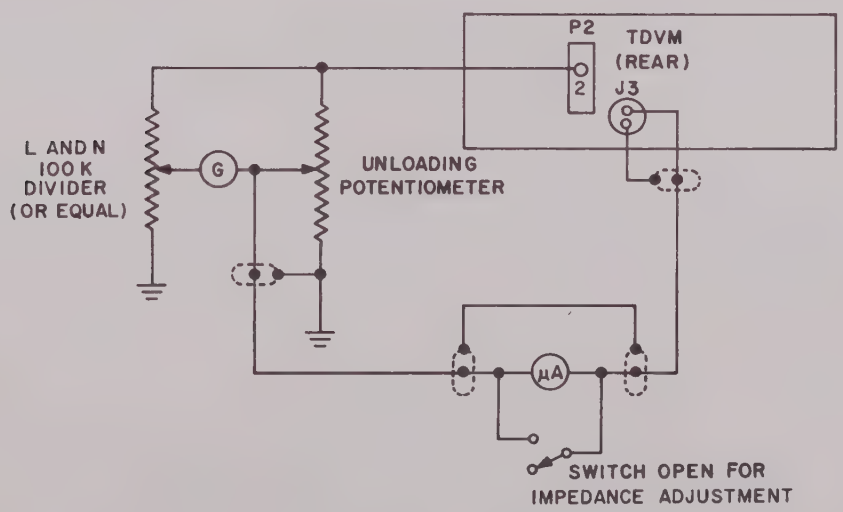


Figure 28. TDVM Unloading Adjustment, Test Setup

(e) Switch the INPUT IMPEDANCE switch to the 10M position (with the 10 volts still applied).

(f) Adjust R3 (NW7) for 1 microampere of current. This sets the input impedance to 10 megohms.

(g) Close the meter bypass switch and set the TDVM to the 1 volt range. Apply an input of 1.000 volt.

(h) Set the INPUT IMPEDANCE switch to the MAX position. Open the bypass switch and adjust R2 (NW7) for minimum current through the microammeter (maximum allowable reading of 0.004 microamperes). This sets the input impedance to 250 megohms or greater.

(i) Switch the INPUT IMPEDANCE switch to the 10M position.

(j) Adjust R1 (NW7) for 0.1 microampere of current. This sets the input impedance to 10 megohms.

3. OHMS SECTION (5003 Only)

To calibrate the 5003A TDVOM, use the procedure in Section 2 above, and then proceed with the following four additional steps.

a. Set the power switch to STANDBY, the RANGE switch to 100K.

b. Connect a precision 97.775 (±0.001%) kilohm resistor between the input probes.

c. Zero set the display indicators and then set the power switch to ON.

d. Adjust R28p on the 12.687-1 Card (NW7) until the display flickers between 097.77 and 097.78.

4. AC-DC CONVERTER

The AC-DC Converter calibration procedures are divided into two groups: DC calibration and AC calibration. The converter should be DC calibrated any time the DC gain check in Section 2*c.*(1) of Chapter V indicates an error. The AC calibration procedure should be performed only if precision components affecting these adjustments are replaced. The converter must be DC calibrated prior to AC calibration.

a. DC Calibration

The following DC calibration procedure requires a Leeds and Northrup 100K Null Voltage Test Set (or equivalent), a galvanometer, a high resolution potentiometer (Helipot, Model 30,000 A-1, or equal), and a stable DC source of approximately ±100 volts.

NOTE

Before proceeding with the calibration procedure, remove the two chassis from the rack or dust cover, reconnect the junction box connector, apply an appropriate AC source, and allow the unit to warm up for at least 30 minutes.

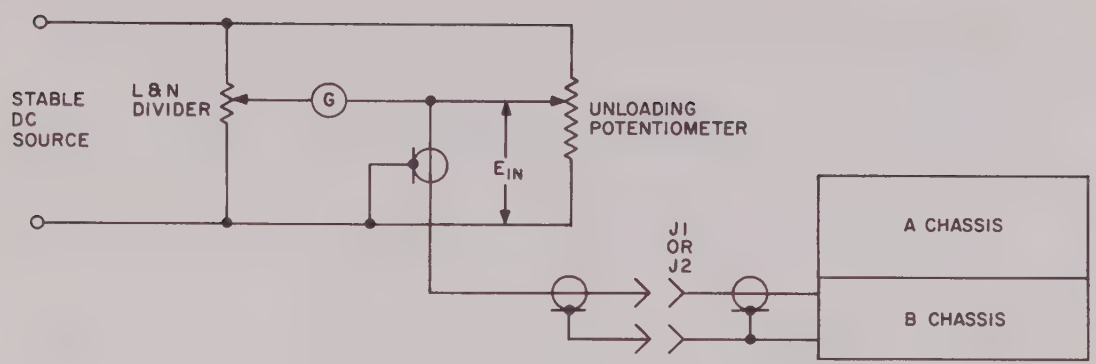


Figure 29. DC Calibration Test Setup

(1) Set up the test circuit shown in Figure 29.

(2) Set the 5002 and 5003 switches as indicated below:

TRIGGER .....INT

OFF-STANDBY-ON ..... ON

RANGE (A chassis) ..... REMOTE

INPUT IMPEDANCE 10M

POWER ..... on

RANGE (B chassis) ..... as directed

MODE ..... as directed

(3) Set the MODE switch to DC, and the B chassis RANGE switch to the range listed in Table XI. With a negative DC source, adjust the L & N Divider for the reading indicated in the E_{in} column of Table XI.

TABLE XI. DC Calibration Test Data

Step	Range	E_{in}	AC	Neg. Adjust	Pos. Adjust
1	1 volt	-1.0000	AC1.1107 ±3 digits	R9 on NW3	
2	1 volt	+1.0000	AC1.1107 ±3 digits		R16 on NW3
3	10 volts	-10.000	AC11.107 ±3 digits	R6 on NW3	
4	10 volts	+10.000	AC11.107 ±3 digits		R17 on NW3
5	100 volts	-100.00	AC111.07 ±3 digits	R7 on NW3	
6	100 volts	+100.00	AC111.07 ±3 digits		R18 on NW3
7	1000 volts	-100.00	AC0111.1 ±3 digits	R8 on NW3	
8	1000 volts	+100.00	AC0111.1 ±3 digits		R19 on NW3

(4) Adjust the unloading potentiometer for a null on the galvanometer with the reading indicated above.

(5) Change the MODE switch to AC. Readjust the unloading potentiometer for a null on the galvanometer. The instrument should now read the value indicated under the AC column of Table XI.

(6) If the reading obtained in Paragraph 5 is not within the specified tolerance, adjust the potentiometer listed in the NEG ADJUST column of Table XI to obtain the specified reading.

(7) Apply a positive DC source. Adjust the L & N Divider for the reading indicated under the E_{in} column in Table XI.

(8) Repeat Paragraphs 4 and 5.

(9) If the reading is not within tolerance, adjust the potentiometer listed in the POS ADJUST column of Table XI to obtain the specified reading.

(10) Repeat Paragraphs 3 through 9 for each step listed in Table XI.

b. AC Calibration

The following AC Calibration procedure must be carefully performed with high precision test equipment. Prior to AC Calibration, the TDVM or TDVOM should be calibrated, and the AC-DC Converter should be DC calibrated.

To attain the specified accuracy in the 49.038, the following test equipment standards must be strictly adhered to. The accuracy of the AC thermocouple when the primary current is reversed must be 0.005% or better. The audio generator must have less than 0.2% harmonic distortion (measured with a harmonic analyzer). Other test equipment required is a Leeds and Northrup 100K Null Voltage Test Set, two galvanometers, and a 100 VDC ±0.005% reference supply.

Prior to starting this procedure, make a test chart similar to the one shown in Figure 30.

Range	V_i (Volts)	Frequency											
		50 CPS	130 CPS	400 CPS	800 CPS	1 KC	1.6 KC	2 KC	2.5 KC	3 KC	5 KC	8 KC	10 KC
1V	0.1												
	0.5												
	1.0												
10V	1.0												
	5.0												
	10.0												
100V	10.0												
	50.0												
	100.0												
1000V	100.0												

Figure 30. AC Calibration Test Chart (Percent Error of Full-Scale verses Frequency)

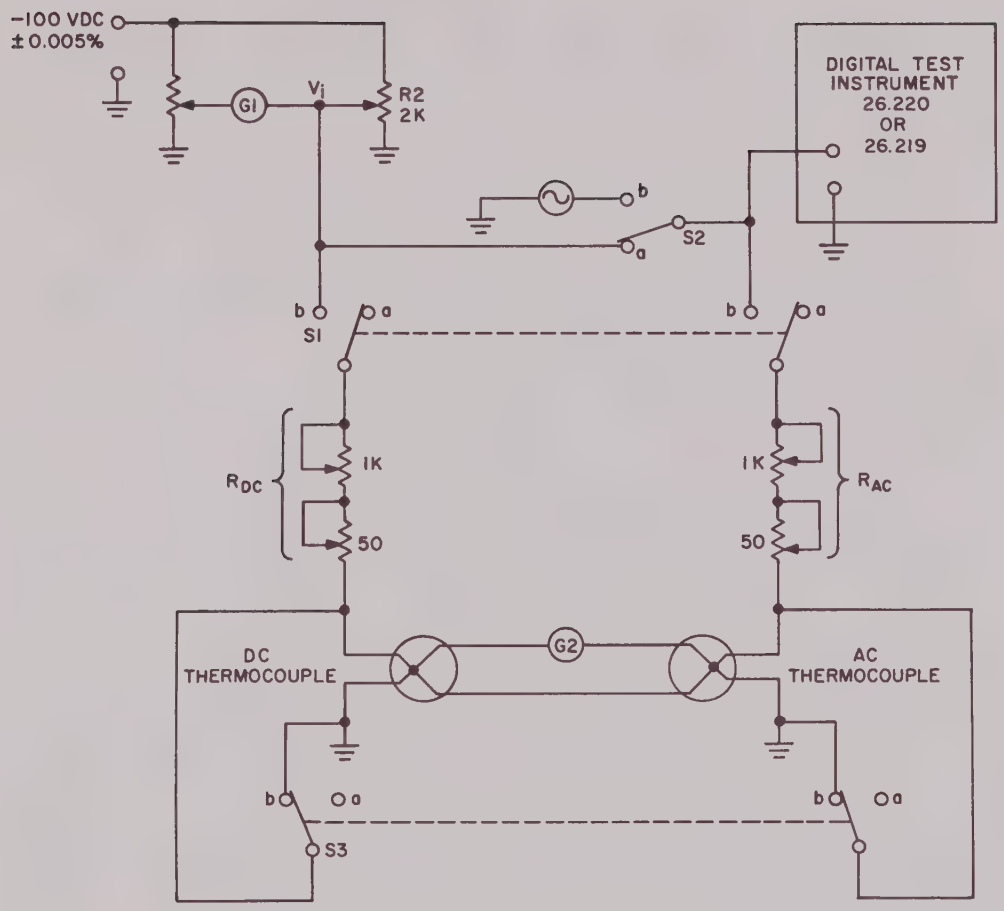


Figure 31. AC Calibration Test Setup

(1) *1 Volt Range Calibration*

(a) Set up the test circuit shown in Figure 31. Switch S3 in this circuit is a safety feature and although not essential for circuit operation, it prevents possible accidental destruction of the thermocouples.

(b) Set switches S1, S2, and S3 to position a.

(c) Set the TDVM or TDVOM to internal trigger and the AUTO or AUTO V range. Set the AC-DC Converter to AC MODE and AUTO.

(d) Set the L & N Test Set to 001000.

(e) Zero galvanometer G1 by adjusting R2.

(f) Operate switch S1 to position b.

(g) Zero G2 with R_{AC} or R_{DC}. Hold G1 balanced with R2.

(h) Record the digital test instrument reading. This reading should be 1.1107 ±0.03% of full scale.

(i) Operate S2 to position b.

(j) Rezero G1 with R2.

(k) Operate S3 to position a.

(l) Rezero G1 with R2 and zero G2 by varying the audio generator output amplitude.

(m) Record the digital test instrument reading. This reading should be 1.0000 ±0.07% of full scale. Record, the percent of error on the chart produced from Figure 31.

(n) Repeat the above procedure for each of the V_i and Frequency Listings on Table XII. Adjust NW3-C7 until all readings are within the indicated tolerance.

TABLE XII. AC Calibration, 1 Volt Range Settings

L & N Settings	V_i	Required TDVM Reading With DC Input on AC	Required TDVM Reading With AC Input on AC	Frequency
001000	-1.0000V	1.1107V ±.03% of FS	1.0000V ±.07% of FS	50 CPS-5 KC
001000	-1.0000V	1.1107V ±.03% of FS	1.0000V ±.12% of FS	5 KC-10 KC
000500	-0.5000V	0.5554V ±.03% of FS	0.5000V ±.07% of FS	50 CPS-5 KC
000500	-0.5000V	0.5554V ±.03% of FS	0.5000V ±.12% of FS	5 KC-10 KC
000100	-0.1000V	0.1111V ±.03% of FS	0.1000V ±.07% of FS	50 CPS-5 KC
000100	-0.1000V	0.1111V ±.03% of FS	0.1000V ±.12% of FS	5 KC-10 KC

(2) *10 Volt Range Calibration.* For the 10 volt range calibration use the procedure listed in Section (1) above substituting the settings listed in Table XIII. Adjust NW3-C1 until all readings are within the indicated tolerance.

TABLE XIII. AC Calibration, 10 Volt Range Settings

L & N Settings	V_i	Required TDVM Reading With DC Input on AC	Required TDVM Reading With AC Input on AC	Frequency
010000	-10.000V	11.107V ±.03% of FS	10.000V ±.07% of FS	50 CPS-5 KC
010000	-10.000V	11.107V ±.03% of FS	10.000V ±.12% of FS	5 KC-10 KC
005000	-05.000V	05.554V ±.03% of FS	05.000V ±.07% of FS	50 CPS-5 KC
005000	-05.000V	05.554V ±.03% of FS	05.000V ±.12% of FS	5 KC-10 KC
001000	-01.000V	01.1107V ±.03% of FS	01.000V ±.07% of FS	50 CPS-5 KC
001000	-01.000V	01.1107V ±.03% of FS	01.000V ±.12% of FS	5 KC-10 KC

(3) *100 Volt Range Calibration.* For the 100 volt range calibration use the procedure in Section (1) above but substitute the settings listed in Table XIV. Adjust NW3-C3 until all readings are within the indicated tolerance.

TABLE XIV. AC Calibration, 100 Volt Range Settings

L & N Settings	V_i	Required TDVM Reading With DC Input on AC	Required TDVM Reading With AC Input on AC	Frequency
100000	-100.00V	111.07V ±.03% of FS	100.00V ±.07% of FS	50 CPS-5 KC
100000	-100.00V	111.07V ±.03% of FS	100.00V ±.12% of FS	5 KC-10 KC
050000	-50.00V	055.54V ±.03% of FS	050.00V ±.07% of FS	5 CPS-5 KC
050000	-50.00V	055.54V ±.03% of FS	050.00V ±.12% of FS	5 KC-10 KC
010000	-10.00V	011.11V ±.03% of FS	010.00V ±.07% of FS	50 CPS-5 KC
010000	-10.00V	011.11V ±.03% of FS	010.00V ±.12% of FS	5 KC-10 KC

(4) *1000 Volt Range Calibration.* For the 1000 volt range calibration use the procedure in Section (1) above but substitute the settings listed in Table XV. Adjust padded NW3-C4 until all readings are within the indicated tolerance.

TABLE XV. AC Calibration, 1000 Volt Range Settings

L & N Settings	V_i	Required TDVM Reading With DC Input on AC	Required TDVM Reading With AC Input on AC	Frequency
100000	-100.00V	0111.1V ±.03% of FS	0100.0V ±.07% of FS	50 CPS-5 KC
100000	-100.00V	0111.1V ±.03% of FS	0100.0V ±.12% of FS	5 KC-10 KC

APPENDIX I

REPLACEABLE PARTS LISTS

5002 AND 5003 SERIES DIGITAL TEST INSTRUMENTS

This appendix contains a Replaceable Parts List for the equipment described in this manual. In each case, a brief description of the part and a manufacturer's number are listed. Where applicable, a reference symbol (schematic designation) is included. To enable a particular sheet to be readily located, an index precedes the individual spare parts lists.

The category column in the parts list indicates the availability of each listed part so that a replacement part can be obtained as quickly as possible. The components in category A are standard electronic items that are usually available from any commercial electronic supplier. In order to expedite obtaining items of this nature, it is suggested that they be purchased from a local source whenever possible. If necessary these parts may be ordered from EAI.

The components in category B are items that can be obtained from EAI or any of the listed manufacturers. However, in most cases, EAI is in a position to offer the most rapid service on items in this category.

The parts in category C are custom-made components and proprietary items that are available only from EAI. When ordering items of this type, please specify the type number and serial number of the basic unit in which the part is located, as well as the part identification.

Where possible, sufficient information is given for category C items to permit an *electrically-similar* replacement part to be obtained locally. Thus, if desired, a temporary repair may be made while the *exact* replacement is being obtained from EAI. *Note, however, that EAI does not guarantee that the affected unit will operate within specifications when the specified category C part is not used.*

PLEASE NOTE THAT EAI RESERVES THE RIGHT TO MAKE PART SUBSTITUTIONS WHEN REQUIRED. IN ALL CASES EAI GUARANTEES THAT THESE SUBSTITUTIONS ARE ELECTRICALLY AND PHYSICALLY COMPATIBLE WITH THE ORIGINAL COMPONENT.

PARTS LIST INDEX

5002 AUTOMATIC AC-DC TDVM, MODEL 26.220

Model Number	Component	Page
1. 26.158-1	Auto Range Switching TDVM	AI-4
a. 6.463	Dual DC Amplifier	AI-6
b. 6.464	Reference Amplifier	AI-9
c. 12.675	Diode Network	AI-12
d. 12.687	Network Card	AI-13
e. 12.722	Reference Amplifier Network	AI-15
f. 14.156	Automatic Range Switching Circuits	AI-16
g. 26.096-3	Comparator and Diode Gate	AI-18
(1) 26.134-2	Comparator Amplifier	AI-18
h. 26.116	Summing Resistor Network	AI-19
i. 43.094-1	Power Supply Regulator	AI-21
j. 44.139-1	Binary Coded Decade Counter	AI-23
k. 44.139-5	Binary Coded Decade Counter	AI-24
l. 44.170-3	Programmer	AI-25
m. 51.010-1	Readout Storage Decade	AI-27
n. 51.080-1	Readout Storage Decade	AI-28
2. 49.038	AC-DC Converter	AI-29
a. 6.334	Dual DC Amplifier	AI-30
b. 6.617	Dual DC Amplifier	AI-33
c. 11.158	Command Relay Drive	AI-36
d. 12.884	Resistor Network	AI-37
e. 12.889	Amplifier Network	AI-39
f. 12.890	Amplifier Network	AI-40
g. 43.031-2	Power Supply Regulator	AI-41

5003 AUTOMATIC MULTIMETER, MODEL 26.219

Model Number	Component	Page
1. 26.212-1	Automatic Range TDVOM	AI-42
a. 6.463	Dual DC Amplifier	AI-6
b. 6.464	Reference Amplifier	AI-9
c. 11.159	Input Switching Relays	AI-44
d. 12.675	Diode Network	AI-12
e. 12.687-1	Network Card	AI-45
f. 12.722	Reference Amplifier Network	AI-15
g. 14.156	Automatic Range Switching Circuits	AI-16
h. 26.096-3	Comparator and Diode Gates	AI-18
(1) 26.134-2	Comparator Amplifier	AI-18
i. 26.116	Summing Resistor Network	AI-19
j. 43.094-1	Power Supply Regulator	AI-21
k. 44.139-1	Binary Coded Decade Counter	AI-23
l. 44.139-5	Binary Coded Decade Counter	AI-24
m. 44.170-3	Programmer	AI-25
n. 51.010-1	Readout Storage Decade	AI-27
o. 51.080-1	Readout Storage Decade	AI-28
2. 49.038	AC-DC Converter	AI-29
a. 6.334	Dual DC Amplifier	AI-30
b. 6.617	Dual DC Amplifier	AI-33
c. 11.158	Command Relay Drive	AI-36
d. 12.884	Resistor Network	AI-37
e. 12.889	Amplifier Network	AI-39
f. 12.890	Amplifier Network	AI-40
g. 43.031-2	Power Supply Regulator	AI-41

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	B1	Fan, Muffin Venturi; 110V 60 cps, 13 Watts; Rotron Mfg. Co.	B242 022 1	C
2	C1	Capacitor, Fixed, Electrolytic: 4000 UF, 15V Sprague TVL-1173	516 044 0	A
3	C2	Capacitor, Fixed, Electrolytic (Dual): 200-200 UF +100% -10% 250V; P.R. Mallory FP217.74	516 139 0	A
4	C3-5	Capacitor, Fixed, Electrolytic: 2000 UF, 50V P.R. Mallory WP TS-17123	516 239 0	B
5	C6	Capacitor, Fixed, Paper: .5 UF ±10%, 600V; Sprague BP506	520 074 0	A
6	C7	Capacitor, Fixed, Plastic: .47 UF ±5%, 150V Southern Electronics	521 059 0	C
7	CR1-4	Rectifier, Silicon: Hughes Semi-Conductor HR 10212	614 034 0	B
8	DSI-4	Digital Display Indicator: Industrial Electronic Engineers, Inc. 10984-47	B554 016 0	C
9	DS5	Digital Display Indicator: Industrial Electronic Engineers, Inc. 10B06-47	B554 022 0	C
10	F1	Fuse, Cartridge, Slow Acting Type: 1 amp, 125V; Littelfuse 313001	570 111 0	A
11	K1	Relay: 430 ohm DC Coil, 4 Form C Contacts; Allied Controls T-154X-158	B618 157 0	C
12	K2,3	Relay: 24V DC Coil, 4 Form C Contacts; C.P. Clare Type J Code 22 A296341	B618 165 0	C
13	NW1	Resistor Network	C012 725 0	C
14	Q1-4	Transistor, Germanium: PNP, Bendix 2N1136A Type	686 066 0	B
15	R1-S4	Switch, Rotary and Resistor, Variable: 10K ohms	C658 195 0	C
16	R2,3	Resistor, Variable, Composition: 10K ohms ±20%, 1/2W; Allen-Bradley Type G	A642 364 0	A

*NOTE: THE CATEGORY COLUMN IS DESIGNED TO INDICATE AVAILABILITY OF PARTS.
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DATE 3 / 6 / 63

UNIT TITLE

AUTO RANGE SWITCHING TDVM

MODEL NO.

26.158-1

Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R5,6	Resistor, Fixed, Wirewound: 20 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 421 0	B
18	R7	Resistor, Fixed, Wirewound: 33 ohms ±5%, 2W; Ward Leonard 2X33	636 425 0	A
19	R8	Resistor, Fixed, Wirewound: 100 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 422 0	B
20	R9	Resistor, Fixed, Wirewound: 82 ohms ±5%, 2W; Ward Leonard 2X82	636 426 0	A
21	R10,12	Resistor, Fixed, Composition: 6.8 ohms ±5%, 1W; Allen-Bradley GB	627 689 0	A
22	R11	Resistor, Fixed, Wirewound: 1.5 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 423 1	B
23	R13	Resistor, Fixed, Composition: 6.8K ohms ±10% 2W; Allen-Bradley HB	628 682 1	A
24	R14	Resistor, Fixed, Composition: 470 ohms ±10% 1/2W; Allen-Bradley EB	626 471 1	A
25	S2	Switch, Toggle: DPDT; Microswitch 6AT3	664 029 0	B
26	S3,8	Switch, Rotary (Dual): 2 Sections; Centralab 31-1091-2	C658 194 0	C
27	S5,7	Switch, Rotary and Push: Centralab PA-037 and Grayhill Inc. 23-1	C658 196 0	C
28	T1	Transformer, Power: 105V/117V/125V, 50/60 cps Primary, 2EA 39 VCT 1 EA 36 VCT 1 EA 6.3V and 1 EA 220VCT Secondaries; Sterling ST26280	B684 172 0	C

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DATE 3 / 6 / 63

UNIT TITLE

AUTO RANGE SWITCHING TDVM

MODEL NO.

26.158-1 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,10	Capacitor, Fixed, Electrolytic: .47UF, 50V	B521 033 0	C
2	C2,9,11,18	Capacitor, Fixed, Electrolytic: 1250UF +100%-10%, 3V; Callins Industries, Inc. PSS Series	A516 184 0	C
3	C3,12	Capacitor, Fixed, Ceramic: 100PF ±10%, 1000V Cornell-Dubilier L10T1	515 019 0	A
4	C4,13	Capacitor, Fixed, Ceramic: .015UF ±20%, 500V; Sprague Electric 33C30A	515 140 0	B
5	C5, 14	Capacitor, Fixed, Ceramic: 47 PF ±10% 1000V; Cornell-Dubilier L10Q47	515 017 0	A
6	C6,15,19, 20	Capacitor, Fixed, Ceramic: 1000 PF ±20% 75V; Glenco Min-Z-1000-M	515 075 0	B
7	C7,16	Capacitor, Fixed, Electrolytic: .22UF, 50V	B521 134 0	C
8	C8,17	Capacitor, Fixed, Electrolytic: 4.7 UF ±10% 35V; Sprague Products 150D475X9035B2	516 246 0	A
9	C21,22	Capacitor, Fixed, Ceramic: 8PF ±10%, 1000V; Cornell-Dubilier C10V8C	515 087 0	A
10	C23,24	Capacitor, Fixed, Ceramic: .05 UF +100%-20% 30V; Centralab DA-503	515 183 0	A
11	CR1-4	Rectifier, Silicon: Hughes Semi-Conductors HR10212	614 034 0	B
12	CR5-8	Diode, Germanium: Clevite CTP462 Type	614 043 0	B
13	D1	Chopper: 6.3V 60 cps Coil, DPDT BBM Contacts; James Electronics C-2335	530 042 0 ✓	C
14	DSI-4	Lamp, Incandescent: 330 Type	578 020 0	A
15	Q1,2,9,10	Transistor, Germanium: PNP; General Transistor Corp. GT1236	B686 028 0	C
16	Q3,4,8,11, 12,16	Transistor, Germanium: PNP; Motorola 2N652 Type	686 084 0	B
17	Q5,13	Transistor, Silicon: NPN; RCA 2N1700 Type	686 082 0 ✓	A

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DATE 7 / 1 / 62

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.463 Sh.1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
18	Q6,7,14,15	Transistor, Germanium: PNP; Industro	B686 132 0	B
19	Q17,18,19, 20,21,22	Transistor, Germanium: NPN;2N169A Type	686 036 0	A
20	R1,27	Resistor, Fixed, Composition: 5.6 Megohms ±10%, 1/2W; Allen-Bradley EB	626 565 1	A
21	R2,28	Reistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A
22	R3,35	Resistor, Fixed, Composition: 1.8K ohms ±10% 1/2W; Allen-Bradley Eb	626 182 1	A
23	R4,36	Resistor, Fixed, Composition: 2.2K ohms ±10% 1/2W; Allen-Bradley EB	626 222 1	A
24	R5,29	Resistor, Fixed, Composition: 1.6K ohms ±5% 1/2W; Allen-Bradley EB	626 162 0	A
25	R6,37	Resistor, Fixed, Composition: 8.2K ohms ±5% 1/2W; Allen-Bradley EB	626 822 0	A
26	R7,30	Resistor, Fixed, Composition: 100 ohms ±10% 1/2W; Allen-Bradley EB	626 101 1	A
27	R8,31	Resistor, Fixed, Composition: 3.3K ohms ±5% 1/2W; Allen-Bradley EB	626 332 0	A
28	R9,32	Resistor, Fixed, Composition: 18 ohms ±10% 1/2W; Allen-Bradley EB	626 180 1	A
29	R10,33	Resistor, Fixed, Composition: 560K ohms ±10% 1/4W; Allen-Bradley CB	625 564 1	A
30	R11,15,25, 26,34,39, 53,54,59,60	Resistor, Fixed, Composition: 100K ohms ±10% 1/2W; Allen-Bradley EB	626 104 1	A
31	R12,40	Resistor, Fixed, Composition: 33K ohms ±10% 1/2W; Allen-Bradley EB	626 333 1	A
32	R13,41	Resistor, Fixed, Composition: 5.6K ohms ±5% 1/2W; Allen-Bradley EB	626 562 0	A
33	R14,38	Resistor, Fixed, Composition: 560K ohms ±10% 1/2W; Allen-Bradley	626 564 1	A
34	R16,17,46, 48	Resistor, Fixed, Composition: 22K ohms ±10% 1/4W; Allen-Bradley CB	625 223 1	A

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B - INDICATES PARTS THAT CAN BE PURCHASED LOCALLY OR FROM EAI.
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THE PROPER EAI PART SHOULD BE INSTALLED FOR CATEGORY C ITEMS. A COMPLETE DESCRIPTION IS GIVEN TO PROVIDE FOR TEMPORARY REPAIRS; HOWEVER, EAI WILL NOT BE RESPONSIBLE IF UNIT IS NOT WITHIN SPECIFICATIONS UNDER THESE CONDITIONS.

DATE 7 / 1 / 62

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.463 Sh.2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
35	R18,50	Resistor, Fixed, Composition: 3.9K ohms ±10% 1/4W; Allen-Bradley CB	625 392 1	A
36	R21,22,42, 43	Resistor, Fixed, Composition: 47K ohms ±10% 1/2W; Allen-Bradley EB	626 473 1	A
37	R23,45	Resistor, Fixed, Composition: 220K ohms ±10% 1/2W; Allen-Bradley EB	626 224 1	A
38	R61,62	Resistor, Fixed, Composition: 47 megohms ±10%, 1/2W; Allen-Bradley EB	626 476 1	A
39	R57,58	Resistor, Fixed, Composition: 150 ohms ±10% 1/2W; Allen-Bradley EB	626 151 1	A

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DATE 7 / 1 / 62

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.463 Sh. 3 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed. Electrolytic: 55UF +20-15% 15V; Sprague 109D556C2015F2	516 188 0	B
2	C3,5	Capacitor, Fixed, Ceramic: 100PF ±10% 1000V; Cornell-Dubilier L10T1	515 019 0	A
3	C4,6,20	Capacitor, Fixed, Ceramic: .01UF +60%-40% 150V; Centralab DDM-103	515 151 0	A
4	C8	Capacitor, Fixed, Electrolytic: 5UF +20%-15% 50V; Sprague 109D505C2050C2	516 186 0	B
5	C9,11	Capacitor, Fixed, Electrolytic: 1250UF +100 -10%, 3V; Callins Industries PSS Series	A516 184 0	C
6	C10	Capacitor, Fixed, Electrolytic: 5UF +100%-10% 25V; Callins Industries PSS Series	A516 182 0	C
7	C23,27	Capacitor, Fixed, Ceramic: 1000PF GMV, 600V Cornell-Dublier BYA601	515 005 0	A
8	C24	Capacitor, Fixed, Ceramic: 2200PF GMV. 1000V Cornell-Dubilier BYA10D22	515 006 0	B
9	CR1,2	Rectifier, Silicon: Solitron Devices CER71C	614 137 0	B
10	CR3	Diode, Zener: Silicon; Texas Instrument IN759	614 091 0	B
11	CR4,5	Rectifier: Silicon; Hughes Semi-Conductors HR10212	614 034 0	B
12	CR6	Diode: Germanium; Clevite CTP462	614 043 0	B
13	CR10	Diode, Silicon: Zener; Motorola 3/4M47Z10	614 138 0	B
14	D1	Chopper: 6.3V, 60 CPS Coil; BBM; SPDT Contacts; Airpax A-175	530 003 0	C
15	Q1	Transistor, Germanium: PNP; Bendix 2N1136A	686 066 0	B
16	Q2,3,7,12	Transistor, Germanium: PNP; 2N321 Type	686 004 0	A
17	Q5,9,10	Transistor, Germanium: PNP; Industro	B686 032 0	B
18	Q6,11	Transistor, Germanium: PNP; Motorola 2N652	686 084 0	B
19	Q8	Transistor, Germanium: PNP 2N235A Type	686 034 0	A

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DATE 7 / 1 / 62

UNIT TITLE

REFERENCE AMPLIFIER

MODEL NO

6.464 Sh.1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
20	R1,29,35	Resistor,Fixed, Composition: 22K ohms ±10% 1/2W; Allen-Bradley EB	626 223 1	A
21	R2	Resistor, Fixed, Composition: 27K ohms ±10% 1W; Allen-Bradley GB	627 273 1	A
22	R3,26,45	Resistor, Fixed, Composition: 2.7K ohms ±10% 1/2W; Allen-Bradley EB	626 272 1	A
23	R4,7	Resistor, Fixed, Composition: 15K ohms ±10% 1W; Allen-Bradley GB	627 153 1	A
24	R5	Resistor, Fixed, Composition: 1.2K ohms ±10% 1/2W; Allen-Bradley EB	626 122 1	A
25	R6	Resistor, Variable, Wirewound: 2K ohms ±10% .25W; Bourns 200L-1-202	642 080 0	B
26	R8,22,23, 27	Resistor, Fixed, Composition: 68K ohms ±10% 1/2W; Allen-Bradley EB	626 683 1	A
27	R9	Resistor, Variable, Wirewound: 10K ohms ±10% .25W; Bourns 200L-1-103	642 082 0	B
28	R10	Resistor, Fixed, Film: 3300 ohms ±1%, 1/2W International Resistance Corp. DCC Type	634 293 0	B
29	R12	Resistor, Variable, Wirewound: 200 ohms ±5% 1W; Daystrom Pacific Corp. 300-00 Type	B642 201 0	B
30	R13	Resistor, Fixed, Composition: 1K ohms ±10% 1/2W; Allen-Bradley EB	626 102 1	A
31	R15,17,39	Resistor, Fixed, Composition: 4.7K ohms ±10% 1/2W; Allen-Bradley EB	626 472 1	A
32	R16	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W;Allen-Bradley EB	626 332 1	A
33	R18	Resistor, Fixed, Composition: 12K ohms ±10% 1/2W; Allen-Bradley EB	626 123 1	A
34	R19	Resistor, Fixed, Composition: 33K ohms ±10% 1/2W;Allen-Bradley EB	626 333 1	A
35	R20	Resistor, Fixed, Composition: 1.8K ohms ±5% 1/2W; Allen-Bradley EB	626 182 0	A
36	R21	Resistor, Fixed, Composition: 6.8K ohms ±10% 1/2W; Allen-Bradley EB	626 682 1	A

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DATE 7/1/62

UNIT TITLE

REFERENCE AMPLIFIER

MODEL NO.

6.464 Sh.2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
37	R24	Resistor, Fixed, Composition: 100 ohms ±10% 1/2W; Allen-Bradley EB	626 101 1	A
38	R25,38	Resistor, Fixed, Composition: 2.2K ohms ±10% 1/2W; Allen-Bradley EB	626 222 1	A
39	R27	Resistor, Fixed, Composition: 33 ohms ±10% 1/2W; Allen-Bradley EB	626 330 1	A
40	R30,34	Resistor, Fixed, Composition: 10K ohms ±10%, 1/2W; Allen-Bradley EB	626 103 1	A
41	R31,36	Resistor, Fixed, Composition: 220 ohms ±10% 1/2W; Allen-Bradley EB	626 221 1	A
42	R32	Resistor, Rixed, Composition: 120K ohms ±10% 1/2W; Allen-Bradley EB	626 124 1	A
43	R43	Resistor, Fixed, Film: 700 ohms ±1%, 1/2W, Weston 9852B Type	634 339 0	B
44	R44	Resistor, Fixed, Composition: 15K ohms ±10% 1/2W; Allen-Bradley EB	626 153 1	A
45	R48	Resistor, Fixed, Composition: 1.8K ohms ±10% 1/2W; Allen-Bradley EB	626 182 1	A
46	R49	Resistor, Fixed, Composition: 1.2K ohms ±10% 1W; Allen-Bradley GB	627 122 1	A
47	R50	Resistor, Fixed, Film: 22,000 ohms ±1%, 1/2W International Resistance Corporation, DCC	634 296 0	A
48	R51	Resistor, Fixed, Composition: 100 ohms ±10% 2W; Allen-Bradley HB	628 101 1	A
49	R52	Resistor, Fixed, Film: 8.2K ohms ±1%, 1/2W International Resistance Corp., DCC Type	634 294 0	A
50	R53	Resistor, Fixed, Film: 15,000 ohms ±1%, 1/2W International Resistance Corp., DCC Type	634 295 0	A
51	R54	Resistor, Variable, Wirewound; 20 ohms ±5% 1W; Daystrom-Pacific 300-00	B642 419 0	B
52	Z1	Oven, Zener	6.210	C

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DATE 7 /1 / 62

UNIT TITLE

REFERENCE AMPLIFIER

MODEL NO.

6.464- Sh. 3 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1-16	Diode, Silicon: Diodes Inc. DI-51	A614 109 0	C

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DATE 7 / 1 / 62

UNIT TITLE
DIODE NETWORK

MODEL NO.
12.675 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C2	Capacitor, Fixed, Electrolytic: 2 UF +100% 15%, 25V, Sprague TE-1201	516 236 0	A
2	C3,4	Capacitor, Fixed, Ceramic: 3000 PF ±20% 75V; Glenco Min-K-3000-M	515 149 0	B
3	C5	Capacitor, Fixed, Ceramic: 4700PF ±20% 1000V; Cornell-Dublier BYA10D47M	515 008 0	A
4	C6,10	Capacitor, Fixed, Ceramic: 1000PF GMV 600V; Cornell-Dublier BYA6D1	515 005 0	A
5	C7	Capacitor, Fixed, Ceramic: 330 PF ±10%, 500V; Erie Resistor Corp. GP2K-330 ±33	515 044 0	A
6	CR4,5, 8,9,11,12, 14,15	Diode, Germanium: Clevite CTP462	614 043 0	B
7	CR6,10	Diode, Silicon: Continental Device Corp. CD1282	B614 117 0	C
8	CR7,13	Diode, Silicon: Zener; Motorola 1/4M17Z5	614 118 0	B
9	Q1-4	Transistor, Germanium: PNP; Industro	B686 032 0	C
10	R1	Resistor, Variable, Wirewound: 500 ohms ±10% 1/4W; Bournes Laboratories 200P-1-501	642 316 0	B
11	R1p	Resistor, Fixed, Wirewound, Precision: 250 ohms ±2 ohms; Resistance Products; L21X Type	Order by Description	C
12	R2,3	Resistor, Variable, Wirewound: 100 ohms ±10% 1/4W; Bournes Laboritories 200P-1-101	642 314 0	B
13	R2p	Resistor, Fixed, Wirewound, Precision: 300 ohms ±2 ohms; Resistance Products L21X Type	Order by Description	C
14	R3p	Resistor, Fixed, Wirewound, Precision: 200 ohms ± 2 ohms; Resistance Products L21X Type	Order by Description	C
15	R4	Resistor, Variable, Wirewound: 50 ohms ±10% 1/4W; Borns Laboratories 200P-1-500	642 313 0	B
16	R4p	Resistor, Fixed, Wirewound, Precision: 100 ohms ±1 ohm; Resistance Products L21X Type.	Order by Description	C

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DATE 7/1/62

UNIT TITLE
NETWORK CARD

MODEL NO.
12.687

Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R5	Resistor, Fixed, Composition: 100K ohms ±10% 1/2W; Allen-Bradley EB	626 104 1	A
18	R6	Resistor, Fixed, Composition: 22K ohms ±10% 1/2W; Allen-Braley EB	626 223 1	A
19	R7,10	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A
20	R8	Resistor, Fixed, Composition: 15K ohms ±10% 1/2W; Allen-Bradley EB	626 153 1	A
21	R9	Resistor, Fixed, Composition: 68K ohms ±10% 1/2W; Allen-Bradley EB	626 683 1	A
22	R11	Resistor, Fixed, Composition: 18K ohms ±10% 1/2W; Allen-Bradley EB	626 183 1	A
23	R12,13,25, 26	Resistor, Fixed, Composition: 10K ohms ±10% 1/2W; Allen-Bradley	626 103 1	A
24	R14	Resistor, Variable, Wirewound: 10 ohms ±10% 2W; Athom Electronics 114-100	642 534 0	B
25	R14p	Resistor, Fixed, Wirewound, Precision: 28 ohms ±1%, 1/4W; Resistance Prod. Co. L-21X Type	Order by Description	C
26	R15	Resistor, Fixed, Wirewound, Precision: 50,000 ohms ±.05%; Julie Research Labs R34 Type	638 046 0	B
27	R16	Resistor, Variable, Wirewound: 20K ohms ±10% 1/4W; Bourns Laboratories 200P-1-203	642 321 0	B
28	R17	Thermister: 10K ohms ±10% at 25°C; General Electric 1D101	646 031 0	B
29	R18	Resistor, Fixed, Composition: 56 ohms ±10% 1/2W; Allen-Bradley EB	626 560 1	A
30	R19, 21	Resistor, Fixed, Wirewound, Precision (Matched Pair) 2EA 10,000 ohms ±.05%	A638 272 0	C
31	R20	Resistor, Variable, Wirewound; 20 ohms ±10% 1/4W; Bourns Laboratories 200P-1-200	642 312 0	B
32	R22,23	Resistor, Fixed, Composition: 12K ohms ±10% 1/2W; Allen-Bradley EB	626 123 1	A
33	R24	Resistor, Fixed, Composition: 56K ohms ±10% 1/2W; Allen-Bradley EB	626 563 1	A

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DATE 7 /6 /62

UNIT TITLE

NETWORK CARD

MODEL NO.

12.687 Sh.2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Plastic: 1 UF ±20%, 200V Hopkins 1P2M	521 056 0	B
2	C2	Capacitor, Fixed, Electrolytic: 20 UF, 150V Cornell-Dubilier BBR 20-150	516 177 0	A
3	R1	Resistor, Fixed, Wirewound, Precision: 8,964 ohms ±.05%, Julie Research Labs R34 Type	A638 317 0	C
4	R2	Resistor, Fixed, Wirewound, Precision: 100,000 ohms ±.05%; Julie Research Labs R34 Type	A638 316 0	C
5	R3	Resistor, Fixed, Film: 60,000 ohms ±1%, 1/2W; Weston 9852B	634 468 0	B

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DATE 7 / 1 / 62

UNIT TITLE

REFERENCE AMPLIFIER NETWORK

MODEL NO.

12.722 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1-1,1-2, 2-1,2-2,3-1,3-2,12, 14,20	Capacitor, Fixed, Ceramic: 1000 PF GMV; 600V Cornell-Dubilier BYA6D1	515 005 0	A
2	C4-1,4-2	Capacitor, Fixed, Electrolytic: 4.7 UF ±5% Sprague 150D475X5035B0	516 234 0	A
3	C11	Capacitor, Fixed, Ceramic: 100 PF ±10%, 1000V Cornell-Dbuilier L10T1	515 019 0	A
4	C13	Capacitor, Fixed, Ceramic: .01 UF+60% -40% 150V; Centralab DDM-103	515 151 0	A
5	C21	Capacitor, Fixed, Ceramic: 560PF ±10%, 150V; Glenco HO-150-Z-560K	515 167 0	B
6	C22	Capacitor, Fixed, Ceramic: 3000 PF ±20%, 75V; Glenco MIN-K-3000M	515 149 0	B
7	C23,24	Capacitor, Fixed, Electrolytic: (value determined at time of manufacture)	Order by description	C
8	CR1-37	Diode, Germanium: Clevite CTP462	614 043 0	B
9	Q1-1,1-2 2-1,2-2,3-1,3-2,4-1, 4-2,5,6,11-14	Transistor, Germanium: PNP; RCA 2N404 Type	686 048 0	A
10	Q7-10	Transistor, Germanium: PNP; Bendix 2N1008B Type	686 022 0	B
11	R1-1,1-2, R2-1,2-2, 22,24	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A
12	R3-1,3-2, 4-1,4-2,9-1,9-2,43, 44	Resistor, Fixed, Composition: 15K ohms ±10% 1/2W; Allen-Bradley EB	626 153 1	A
13	R5-1,5-2, 6-1,6-2,11-1,11-2,45, 46	Resistor, Fixed, Composition: 100K ohms ±10% 1/2W; Allen-Bradley EB	626 104 1	A

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DATE 3 / 4 / 63

UNIT TITLE
AUTOMATIC RANGE SWITCHING CIRCUIT

MODEL NO.
14.156

Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
14	R7-1,7-2, 8-1,8-2	Resistor, Fixed, Composition: 4.7K ohms ±10% 1/2W; Allen-Bradley EB	626 472 1	A
15	R10-1,10-2	Resistor, Fixed, Composition: 22K ohms ±5% 1/2W; Allen-Bradley EB	626 223 0	A
16	R21,53	Resistor, Fixed, Composition: 22K ohms ±10% 1/2W; Allen-Bradley EB	626 223 1	A
17	R23,27,33-40,49,52	Resistor, Fixed, Composition: 10K ohms ±10% 1/2W; Allen-Bradley EB	626 103 1	A
18	R25	Resistor, Fixed, Composition: 8.2K ohms ±10% 1/2W; Allen-Bradley EB	626 822 1	A
19	R26	Resistor, Fixed, Composition: 47K ohms ±10% 1/2W; Allen-Bradley EB	626 473 1	A
20	R28,29,30, 42,47,48, 50,54	Resistor, Fixed, Composition: 3.9K ohms ±10% 1/2W; Allen-Bradley EB	626 392 1	A
21	R31	Resistor, Fixed, Composition: 1.2K ohms ±10% 1/2W; Allen-Bradley EB	626 122 1	A
22	R32	Resistor, Fixed, Wirewound: 4.7 ohms ±10% 1W; International Resistance Co. BW-1 Type	636 118 0	A
23	R41	Resistor, Fixed, Composition: 2.7K ohms ±10% 1/2W; Allen-Bradley EB	626 272 1	A
24	R51	Resistor, Fixed, Composition: 1.8K ohms ±10% 1/2W; Allen-Bradley EB	626 182 1	A

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DATE 3/4/63

UNIT TITLE
AUTOMATIC RANGE SWITCHING CIRCUITS

MODEL NO.
14.156 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR3 5,7 9, 11 thru 35	Rectifier, Silicon: Hughes Semi-Conductors HD 6226	614 034 0	B
2	CR4,6,8,10, 36	Diode, Silicon: Hughes Semi-Conductors IN459 Type	B614 007 0	B
3	HR1,2	Resistor, Heat Pad: Electro-Flex Heat Inc. 1388	646 022 0	B
4	R1	Resistor, Fixed, Film: 56K ohms ±1% 1/4W; Aerovox CPX-1/4	634 432 0	A
5	R2	Resistor, Fixed, Film: 100K ohms ±1%, 1/4W; Aerovox CPX-1/4	634 431 0	A
6	S1	Switch, Thermostat: Fenwall 32,410-1	B662 018 0	B
		COMPARATOR AMPLIFIER 26.134-2		
1	C1	Capacitor, Fixed, Ceramic: 560PF ±10%, 500V Erie Resistor Corp., GP2K-560 ±56	515 047 0	A
2	CR1	Diode, Germanium: Clevite CTP462	614 043 0	B
3	Q1,2	Transistor, Germanium: PNP; Sprague 2N345 Type	686 006 0	B
4	Q3.4,5	Transistor, Germanium: PNP; RCA 2N404 Type	686 048 0	A
5	R1	Resistor, Fixed, Film: 190K ohms ±1%; 1/4W; Aerovox CPX-1/4	634 433 0	A
6	R2,4	Resistor; Fixed, Composition: 1.8K ohms ±10% 1/2W; Allen-Bradley EB	626 182 1	A
7	R3	Resistor, Fixed, Composition: 220 ohms ±10% 1/2W;Allen-Bradley EB	626 221 1	A
8	R5	Resistor, Fixed, Composition: 2.7K ohms ±10% 1/2W; Allen-Bradley EB	626 272 1	A
9	R6,7,8	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A

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DATE 7 / 1 / 62

UNIT TITLE

COMPARATOR AND DIODE GATE

MODEL NO.

26.096-3 Sh.1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	R1	Resistor, Fixed, Wirewound, Precision: 1,249,685 Ohms ± .1%	A638 460 0	C
2	R2	Resistor, Fixed, Film: 12.5 Megohms ± 1%, 2W; Aerovox CPX-2	634 225 0	A
3	R3	Resistor, Fixed, Film: 2.5 Megohms ± 1%, 1/2W; Aerovox CPX-1/2	634 187 0	A
4	R4	Resistor, Fixed, Film: 25 Megohms ± 1%, 2W; Aerovox CPX-2	634 189 0	A
5	R5	Resistor, Fixed, Film: 5 Megohms ± 1%, 1/2W; Aerovox CPX-1/2	634 034 0	A
6	R6	Resistor, Fixed, Film: 50 Megohms ± 1%, 2W; Aerovox CPX-2	634 190 0	A
7	R7	Resistor, Fixed, Film: 10 Megohms ± 1%, 1W; Aerovox CPX-1	634 053 0	A
8	R8	Resistor, Fixed, Film: 100 Megohms ± 2%, 2W; Aerovox CPX-2	634 191 0	A
9	R9	Resistor, Fixed, Wirewound, Precision: 12,442 Ohms ± .05%	A638 452 0	C
10	R9p	Resistor, Variable, Wirewound: 50 Ohms ± 5%, 1W; Daystrom-Pacific Model 301-60	B642 435 0	B
11	R10	Resistor, Fixed, Wirewound, Precision: 124,586 Ohms ± .05%	A638 456 0	C
12	R10p,15p	Resistor, Variable, Wirewound: 500 Ohms ± 5%, 1W; Daystrom-Pacific Model 301-60	B642 438 0	B
13	R11	Resistor, Fixed, Wirewound, Precision: 24,896 Ohms ± .05%	B638 453 0	C
14	R11p	Resistor, Variable, Wirewound: 100 Ohms ± 5%, 1W; Daystrom-Pacific Model 301-60	B642 436 0	B
15	R12	Resistor, Fixed, Wirewound, Precision: 249,749 Ohms ± .05%	A638 457 0	C
16	R13	Resistor, Fixed, Wirewound, Precision: 49,811 Ohms ± .05%	A638 454 0	C
17	R13p	Resistor,Variable, Wirewound: 200 Ohms ± 5%, 1W; Daystrom-Pacific Model 301-60	A642 437 0	B

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UNIT TITLE
SUMMING RESISTOR NETWORK

MODEL NO.
26.116 Sht. 1 of 2

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
18	R14	Resistor, Fixed, Wirewound, Precision: 499,648 Ohms ± .05%	A638 458 0	C
19	R15	Resistor, Fixed, Wirewound, Precision: 99,609 Ohms ± .05%	A638 455 0	C
20	R16	Resistor, Fixed, Wirewound, Precision: 999,598 Ohms ± .05%	A638 459 0	C
21	R17,18	Resistor, Fixed, Wirewound, Precision(Matched Pair): Total Series Resistance to be 1,253 Ohms ± .05%	A638 540 0	C
22	R19	Resistor, Fixed, Composition: 12 Megohms ± 10%, 1/2W' Allen-Bradley EB	626 126 1	A

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UNIT TITLE
SUMMING RESISTOR NETWORK

MODEL NO.
26.116 Sht. 2

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,6,9,12	Capacitor, Fixed, Electrolytic: 55UF +20% -15%, 50V; Sprague 109D55C2050T2	516 237 0	A
2	C2,7,10	Capacitor, Fixed, Electrolytic: 10UF +100% -15%, 15V; Sprague TE-1155	516 238 0	A
3	C3,8,11	Capacitor, Fixed, Electrolytic: 50UF +100% -15%, 25V; Sprague TE-1209	516 149 0	A
4	C4,13	Capacitor, Fixed, Electrolytic: 30UF +100% -15%, 15V; Sprague TE-1158	516 039 0	A
5	C5	Capacitor, Fixed, Electrolytic: 110UF +100% -15%, 3V; Sprague TE-1060	516 043 0	A
6	CR1,3,4,	Diode, Silicon: Zener, Texas Instruments 1N754A Type	614 046 1	B
7	CR2,5	Diode, Silicon: Zener; Texas Instruments 1N759A Type	B614 091 1	B
8	Q1,6,8	Transistor, Germanium: PNP; Motorola 2N652 Type	686 084 0	B
9	Q2,7,9	Transistor, Germanium: PNP; RCA 2N404 Type	686 048 0	A
10	Q3,4,5	Transistor, Germanium: PNP; General Electric 2N321 Type	686 004 0	A
11	R1,2,13,14 20,21	Resistor, Fixed, Composition: 4.7K ohms ±10% 1/2W; Allen-Bradley EB	626 472 1	A
12	R3,15,22	Resistor, Fixed, Composition: 8.2K ohms ±10% 1/2W; Allen-Bradley EB	626 822 1	A
13	R4,16,23,28 29,30	Resistor, Fixed, Compositon: 1K ohms ±10% 1/2W; Allen-Bradley EB	626 102 1	A
14	R6,18,25	Resistor, Variable, Wirewound: 200 ohms ±10% 1W; Bourns Laboratories 26CP-1-201	642 327 0	B
15	R7,19,26	Resistor, Fixed, Composition: 560 ohms ±10% 1/2W; Allen-Bradley EB	626 561 1	A
16	R8	Resistor, Fixed, Composition: 680 ohms ±5% 1/2W; Allen-Bradley EB	626 681 0	A

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DATE 7 / 1 / 62

UNIT TITLE
POWER SUPPLY REGULATOR

MODEL NO.
43.094-1

Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R9	Resistor, Fixed, Compostion: 300 ohms ±5% 1/2W; Allen-Bradley EB	626 301 0	A
18	R11	Resistor, Fixed, Compositon: 1.1K ohms ±5% 1/2W; Allen-Bradley EB	626 112 0	A
19	R12	Resistor, Fixed, Compostion: 200 ohms ±5% 1/2W; Allen-Bradley EB	626 201 0	A
20	R27	Resistor, Fixed, Composition: 2K ohms ±10% 1/2W; Allen-Bradley EB	626 202 1	A

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DATE 7 / 1 / 62

UNIT TITLE
POWER SUPPLY REGULATOR

MODEL NO.
43.094-1

Sh.2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,4,5 Thru 22	Capacitor, Fixed, Ceramic: 1000 UUF ± 10%, 75V; Glenco Min-Z-1000-K	515 145 0	B
2	C2,3	Capacitor, Fixed, Ceramic: 3000 UUF ± 20%, 75V; Glenco Min-K-3000-M	515 149 0	B
3	CR1 Thru 21	Diode, Germanium: Clevite CTP462	614 043 0	B
4	Q1 Thru 12	Transistor, Germanium: PNP; Industro	B686 032 0	B
5	R1,2	Resistor, Fixed, Composition: 4.7K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 472 1	A
6	R3,9,12,17, 19,23,26, 31,35,39,43	Resistor, Fixed, Composition: 15K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 153 1	A
7	R4,10,13,18, 20,24,27,32, 40,44	Resistor, Fixed, Composition: 100K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 104 1	A
8	R5,8,11,14, 25,33,37,38, 47 Thru 52	Resistor, Fixed, Composition: 10K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 103 1	A
9	R6,7,15,16, 21,22,29,30, 41,42	Resistor, Fixed, Composition: 3.3K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 332 1	A
10	R34,36,45	Resistor, Fixed, Composition: 22K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 223 1	A

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UNIT TITLE
BINARY CODED DECADE COUNTER

MODEL NO.
44.139-1

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,4,5 Thru 22	Capacitor, Fixed, Ceramic: 1000 UUF ± 10%, 75V; Glenco Min-Z-1000-K	515 145 0	B
2	C2,3	Capacitor, Fixed, Ceramic: 3000 UUF ± 20%, 75V; Glenco Min-K-3000-M	515 149 0	B
3	CR1-17,19-21,201	Diode, Germanium: Clevite CTP462	614 043 0	B
4	Q1 Thru 12	Transistor, Germanium: PNP;(2N324 Type Mod.)	B686 032 0	C
5	R1,2	Resistor, Fixed, Composition: 4.7K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 472 1	A
6	R3,9,12,17, 19,23,26, 31,35,39,43	Resistor, Fixed, Composition: 15K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 153 1	A
7	R4,10,13,18, 20,24,27,32, 40,44	Resistor, Fixed, Composition: 100K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 104 1	A
8	R5,8,11,14, 25,33,37,38, 47 Thru 52	Resistor, Fixed, Composition: 10K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 103 1	A
9	R6,7,15,16, 21,22,29,30, 41,42	Resistor, Fixed, Composition: 3.3K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 332 1	A
10	R34,36,45	Resistor, Fixed, Composition: 22K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 223 1	A

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UNIT TITLE
BINARY CODED DECADE COUNTER

MODEL NO.
44,130-5

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Ceramic: 220 UUF ± 10%, 600V; Cornell-Dubilier LA-S3	515 020 0	B
2	C2,4 Thru 11, 13 Thru 16	Capacitor, Fixed, Ceramic: 1000 UUF ± 10%, 75V; Glenco Min-Z-1000-K	515 145 0	B
3	C3	Capacitor, Fixed, Ceramic: 5600 UUF GMV, 600V; Centralab D6-562	515 179 0	B
4	C12	Capacitor, Fixed, Ceramic: .47 UF ± 20%, 25V; Sprague 5C11	515 190 0	B
5	CR1 Thru 11, 13	Diode, Germanium: Clevite CTP462	614 043 0	B
6	L1	Coil: 3.3 MH ± 10%; Essex WEE-3300	538 009 0	C
7	Q1 Thru Q14	Transistor, Germanium: PNP;(2N324 Type Mod.)	B 686 032 0	C
8	R1,5,16,17, 18,29,42, 43,52	Resistor, Fixed, Composition: 10K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 103 1	A
9	R2	Resistor, Fixed, Composition: 1.5K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 152 1	A
10	R3,7,36	Resistor, Fixed, Composition: 470 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 471 1	A
11	R4,34,38	Resistor, Fixed, Composition: 1K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 102 1	A
12	R6	Resistor, Fixed, Composition: 270K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 274 1	A
13	R9,10,14, 19,23,27, 32,46,47, 50,53	Resistor, Fixed, Composition: 15K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 153 1	A
14	R11,15,20, 24,25,28, 33,39,48,49	Resistor, Fixed, Composition: 100K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 104 1	A
15	R12,13	Resistor, Fixed, Composition: 820 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 821 1	A
16	R21,22,30, 31,44,45	Resistor, Fixed, Composition: 3.3K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 332 1	A

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UNIT TITLE
PROGRAMMER

MODEL NO.
44.170-3 Sht. 1 of 2

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R26	Resistor, Fixed, Composition: 22K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 223 1	A
18	R51	Resistor, Fixed, Composition: 470K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 474 1	A
19	T1	Transformer, Pulse: Technitrol CB1JA (395.7)	A684 091 0	C

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UNIT TITLE
PROGRAMMER

MODEL NO.
44.170-3 Sht. 2

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1 Thru CR38	Diode, Germanium: Clevite CTP462	614 043 0	B
2	Q1 Thru Q10	Transistor, Germanium: PNP; 2N321 Type	686 004 0	A
3	Q11 Thru Q18	Transistor, Germanium: PNP ; (2N324 Type Modified)	B686 032 0	C
4	R1 Thru R10	Resistor, Fixed, Composition: 1.2K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 122 1	A
5	R11,17,19, 25,26,33, 34,41	Resistor, Fixed, Composition: 22K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 223 1	A
6	R13,16,21, 24,29,32, 37,40	Resistor, Fixed, Composition: 3.3K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 332 1	A
7	R12,14,15, 18,20,22, 23,27,28, 30,31,35, 36,38,39, 42	Resistor, Fixed, Composition: 10K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 103 1	A
8	R43	Resistor, Fixed, Wirewound: 4.7 Ohms ± 10%, 1/2W; International Resistance Co. Type BW 1/2	636 172 0	B

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UNIT TITLE
READOUT STORAGE DECADE

MODEL NO.
51.010-1

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1-56,59-62	Diode, Germanium: Clevite CTP 462 Type	614 043 0	B
2	Q1-10	Transistor, Germanium: PNP; Industro	B686 032 0	C
3	Q11-22	Transistor, Germanium: PNP; General Electric 2N321 Type	686 004 0	A
4	R1,2,9,10, 17,18,25, 26,40,52, 53	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A
5	R3-6, 11-14, 19-22, 27-30,54	Resistor, Fixed, Composition: 10K ohms ±10% 1/2W; Allen-Bradley EB	626 103 1	A
6	R7,8,15,16, 23,24,31, 32	Resistor, Fixed, Composition: 22K ohms ±10% 1/2W; Allen-Bradley EB	626 223 1	A
7	R33-39,41-48,56	Resistor, Fixed, Composition: 1.2K ohms ±10% 1/2W; Allen-Bradley EB	626 122 1	A
8	R49	Resistor, Fixed, Composition: 2.7K ohms ±10% 1W; Allen-Bradley GB	627 279 1	A
9	R50,51,55	Resistor, Fixed, Composition: 5.6K ohms ±10% 1/2W; Allen-Bradley EB	626 562 1	A

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DATE 7/ 1 / 62

UNIT TITLE

READOUT STORAGE DECADE

MODEL NO.

51.080-1 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,2,3	Capacitor, Fixed, Electrolytic: 2500 UF +250% -10%, 25V; P.R. Mallory 20-20979	516 052 0	B
2	CR1,2	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
3	CR3,4,5	Rectifier, Silicon: Hughes Semiconductor HR10212	614 034 0	B
4	DS1	Lamp, Incandescent: General Electric 328	578 010 0	A
5	F1	Fuse, Cartridge, Slow Acting Type: 8/10 Amp. 125V; **Littlefuse** 313.800	570 110 0	A
6	K1,3-5	Relay: 24V DC 500 ohm Coil, 6 Form C contacts, Automatic Electric Sales Corp.	618 194 0	C
7	K2	Relay: 24V DC 300 ohm Coil, 8 Form C Contacts: Automatic Electric Sales Corp. RS-34	618 198 0	C
8	R1-4	Resistor, Variable, Composition: 10K ohms ±20%, 1/2W; Allen Bradley G Type	A642 364 0	B
9	R5	Resistor, Fixed, Wirewound, Precision: 1,000,000 ohms ±.05%, ±.005% Stability Julie Research Labs. H48 Type	B638 827 0	C
10	R6	Resistor, Fixed, Composition: 10 ohms ±5%, 1W; Allen-Bradley GB	627 100 0	A
11	S1,2	Switch, Rotary: 1 Section, 2 Poles, 2-6 Positions; Centralab PA-2003	658 005 0	A
12	S3	Switch, Toggle: SPST; Cutler-Hammer 7501K13	664 009 0	A
13	T1	Transformer, Power: 2 ea 115V 50/60 cps Primaries, 1 ea 6.5V, 1 ea 36 vct, 2 ea 39 vct Secondaries; Freed 35678	B684 200 0	C

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DATE 2 / 8 / 63

UNIT TITLE

AC - DC CONVERTER

MODEL NO.

49.038 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,10	Capacitor, Fixed, Electrolytic: 10 UF ± 20%, 50V; Sprague Electric 109D106X0050C2	516 206 0	B
2	C2,9,11,18	Capacitor, Fixed, Electrolytic: 1250 UF +100%-10%, 3V; Callins Industries, Inc PSS Series	A516 184 0	C
3	C3,12	Capacitor, Fixed, Ceramic: 100 UUF ± 10%, 1,000V; Cornell-Dubilier L10T1	515 019 0	A
4	C4,13	Capacitor, Fixed, Ceramic: .015 UF ± 20%, 500V; Sprague Electric 33C30A	515 140 0	B
5	C5,14	Capacitor, Fixed, Ceramic: 47 UUF ± 10%, 1,000V; Cornell-Dubilier L10Q47	515 017 0	B
6	C6,15,19, 20	Capacitor, Fixed, Ceramic: 1,000 UUF ± 20%, 75V; Glenco Min-Z-1000-M	515 075 0	B
7	C7,16	Capacitor, Fixed, Electrolytic: 5 UF +20%-15%, 50V; Sprague Electric 109D505C2050-CO	516 185 0	B
8	C8,17	Capacitor, Fixed, Electrolytic: 5 UF +100%-10%, 25V; International Electronic Industries	B516 056 0	C
9	C21,22	Capacitor, Fixed, Ceramic: 12 UUF ± 10%, 1000V; Cornell-Dubilier C10Q12C	515 091 0	B
10	C23,24	Capacitor, Fixed, Ceramic: .05 UF +100%-20%, 30V; Centralab DA-503	515 183 0	A
11	CR1-4	Rectifier, Silicon: Hughes Semi-Conductors HR10212	614 034 0	B
12	D1	Chopper: 6.3V, 94 CPS Coil, MBB, DPDT Contacts; James C-2335	530 042 0	C
13	I1 Thru I4	Lamp, Incandescent: 330 Type	578 020 0	A
14	Q1,2,3,9, 10,11	Transistor, Germanium: PNP; General Transistor Corp GT1236	B686 028 0	C
15	Q4,12	Transistor, Germanium: PNP; General Transistor Corp GT1361	686 029 0	B
16	Q5,13	Transistor, Germanium: NPN; General Transistor Corp GT1442	A686 039 0	C

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2/6/63

UNIT TITLE
DUAL DC AMPLIFIER

MODEL NO.
6.334

Sht. 1 of 3 sh

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	Q6,7,8,14, 15,16	Transistor, Germanium: PNP; (2N324 Type Modified)	B686 032 0	C
18	Q17,18	Transistor, Germanium: NPN; 2N169A Type	686 036 0	A
19	R1,27	Resistor, Fixed, Composition: 1 Meg Ohm ± 10%, 1/2W; Allen-Bradley EB	626 105 1	A
20	R2,28	Resistor, Fixed, Composition: 3.3K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 332 1	A
21	R3,35	Resistor, Fixed, Composition: 1.8K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 182 1	A
22	R4,18,36, 50	Resistor, Fixed, Composition: 2.2K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 222 1	A
23	R5,29	Resistor, Fixed, Composition: 1.6K Ohms ± 5%, 1/2W; Allen-Bradley EB	626 162 0	A
24	R6,37	Resistor, Fixed, Composition: 7.5K Ohms ± 5%, 1/2W; Allen-Bradley EB	626 752 0	A
25	R7,30	Resistor, Fixed, Composition: 100 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 101 1	A
26	R8,31	Resistor, Fixed, Composition: 5.1K Ohms ± 5%, 1/2W; Allen-Bradley EB	626 512 0	A
27	R9,32	Resistor, Fixed, Composition: 56 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 560 1	A
28	R10,33	Resistor, Fixed, Composition: 4.7K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 472 1	A
29	R11,14,15, 16,17,34, 38,39,46, 48	Resistor, Fixed, Composition: 10K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 103 1	A
30	R12,40	Resistor, Fixed, Composition: 33K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 333 1	A
31	R13,41	Resistor, Fixed, Composition: 6.2K Ohms ± 5%, 1/2W; Allen-Bradley EB	626 622 0	A
32	R19,20,47, 49	Resistor, Fixed, Composition: 220 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 221 1	A
33	R21,22,42, 43	Resistor, Fixed, Composition: 22K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 223 1	A

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2/6/63

UNIT TITLE
DUAL DC AMPLIFIER

MODEL NO.
6.334 Sht. 2 of 3 sh

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
34	R23,45	Resistor, Fixed, Composition: 120K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 124 1	A
35	R24,44	Resistor, Fixed, Composition: 10 Ohms ± 10%, 1/2W; Allen-Bradley EB	626 100 1	A
36	R25,26,51 Thru 54	Resistor, Fixed, Composition: 68K Ohms ± 10%, 1/2W; Allen-Bradley EB	626 683 1	A
37	R55,56	Resistor, Fixed, Composition: 4.7 Meg Ohms ± 10%, 1/2W; Allen-Bradley EB	626 475 1	A

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2/6/63

UNIT TITLE
DUAL DC AMPLIFIER

MODEL NO.
6.334 Sht. 3 of 3 sh

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,14	Capacitor, Fixed, Ceramic: 12 PF ±10%, 1000V; Cornell-Dubilier C10Q12C	515 091 0	A
2	C2,15	Capacitor, Fixed, Plastic: .47 UF ±20%, 50V	B521 133 0	C
3	C3	Capacitor, Fixed, Electrolytic: 100 UF +30% -10%, 25V; Callins Industries	A516 267 0	C
4	C4,17	Capacitor, Fixed, Plastic: .22 UF ±20%, 50V	B521 134 0	C
5	C5,18	Capacitor, Fixed, Electrolytic: 4.7 UF ±10%, 35V; Sprague 150D475X9035B2	516 246 0	A
6	C6,21	Capacitor, Fixed, Electrolytic: 1250 UF +100%, -10%, 3V; Callins Industries PSS Type	A516 184 0	C
7	C7,19	Capacitor, Fixed, Ceramic: 5.1 PF ±.25 PF, 500V; Vitramon VY04C5R1C	515 242 0	B
8	C8	Capacitor, Fixed, Ceramic: .047 UF ±20%, 25V; Sprague 3C15	515 234 0	B
9	C9,11,22, 24	Capacitor, Fixed, Ceramic: 8 PF ±10%, 1000V; Cornell-Dubilier C10V8C	515 087 0	A
10	C10,23	Capacitor, Fixed, Ceramic: 3900 PF ±10%, 200V; Vitramon, Inc. VK31CW392K	515 237 0	B
11	C12,20,25	Capacitor, Fixed, Ceramic: 1000 PF ±20%, 75V; Glenco Corp. MIN-Z-.001-M	515 075 0	B
12	C13,26	Capacitor, Fixed, Ceramic: 47 PF ±5%, 300V; Vitramon, Inc. YY04C470J	515 233 0	B
13	C16	Capacitor, Fixed, Electrolytic: 800 UF +30%, -10%, 3V; Callins Industries PSS Type	A516 263 0	C
14	CR1,2,7,8	Rectifier, Silicon: Hughes Semiconductor HR10212	614 034 0	B
15	CR3,4,9,10	Diode, Germanium: Clevite CTP462	614 043 0	B
16	CR5,6,11, 12	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
17	D1	Chopper: 6.3V, 60cps Coil, DPDT BBM Contacts; James Electronics C-2335	530 042 0	C

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DATE 2/ / 8 / 63

UNIT TITLE
DUAL DC AMPLIFIER

MODEL NO.
6.617

Sh. 1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
18	DS1-4	Lamp, Incandescent; General Electric 330	578 020 0	A
19	Q1,2,6,12 13,16	Transistor, Silicon: NPN; Motorola 2N2218	638 097 0	B
20	Q3,14	Transistor, Germanium: PNP; Texas Instrument 2N2189	686 098 0	B
21	Q4,15	Transistor, Germanium: NPN: Texas Instrument 2N1308	686 101 0	B
22	Q5,7,9,17 18,20	Transistor, Germanium: PNP; Industro	B686 096 0	C
23	Q8,19	Transistor, Germanium: PNP; Motorola SM635	C686 105 0	C
24	Q10,21	Transistor, Silicon: PNP; Texas Instrument 2N1131	686 099 0	B
25	Q11,22	Transistor, Silicon: NPN; General Electric 2N697	686 100 0	B
26	R1	Resistor, Fixed, Composition: 270 K ohms ±10%, 1/2W; Allen-Bradley EB	626 274 1	A
27	R2,32	Resistor, Fixed, Composition: 82K ohms ±5%, 1/4W; Allen Bradley CB	625 823 0	A
28	R3,33	Resistor, Fixed, Composition: 2.7 MEG ohms ±10%, 1/2W; Allen-Bradley EB	626 275 1	A
29	R4,34	Resistor, Fixed, Composition: 5.6 MEG ohms ±10%, 1/2W; Allen Bradley EB	626 565 1	A
30	R5,6,14,27 29,44,57,59	Resistor, Fixed, Composition: 100K ohms ±10%, 1/2W; Allen-Bradley EB	626 104 1	A
31	R7,12,13, 37,42,43	Resistor, Fixed, Composition: 47K ohms ±10% 1/2W; Allen-Bradley EB	626 473 1	A
32	R8,25, 38, 55	Resistor, Fixed, Composition: 10K ohms ±5% 1/2W; Allen-Bradley EB	626 103 0	A
33	R9,39	Resistor, Fixed, Composition: 1K ohms ±5% 1/4W; Allen-Bradley CB	625 102 0	A
34	R10,40	Resistor, Fixed, Composition: 2.7K ohms ±10% 1/2W; Allen-Bradley EB	626 272 1	A
35	R11,41	Resistor, Fixed, Composition: 4.7K ohms ±5%, 1/4W; Allen-Bradley CB	625 472 0	A

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DATE 2 / 8 / 63

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.617 Sh. 2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
36	R15,45	Resistor, Fixed, Composition: 1.3K ohms ±5%, 1/2W; Allen-Bradley EB	626 132 0	A
37	R16,46	Resistor, Fixed, Composition: 15K ohms ±5% 1/2W; Allen-Bradley EB	626 153 0	A
38	R17,47	Resistor, Fixed, Composition: 220K ohms ±10%, 1/2W; Allen-Bradley EB	626 224 1	A
39	R18,48	Resistor, Fixed, Composition: 22K ohms ±10%, 1/4W; Allen-Bradley CB	625 223 1	A
40	R19,49	Resistor, Fixed, Composition: 150 ohms ±10%, 1/2W; Allen-Bradley EB	626 151 1	A
41	R20,50	Resistor, Fixed, Composition: 1.5K ohms ±5% 1/2W; Allen-Bradley EB	626 152 0	A
42	R21,51	Resistor, Fixed, Composition: 4.7K ohms ±5%, 1/2W; Allen-Bradley EB	626 472 0	A
43	R22,52	Resistor, Fixed, Composition: 1.6K ohms ±5% 1/2W; Allen-Bradley EB	626 162 0	A
44	R23,24, 53,54	Resistor, Fixed, Composition: 100K ohms ±5%, 1/4W; Allen-Bradley CB	625 104 0	A
45	R26,56	Resistor, Fixed, Composition: 22K ohms ±10%, 1/2W; Allen-Bradley EB	626 223 1	A
46	R28,58	Resistor, Fixed, Composition: 2.2K ohms ±5%, 1/2W; Allen-Bradley EB	626 222 0	A
47	R30,60	Resistor, Fixed, Composition: 3.9K ohms ±10%, 1/2W; Allen-Bradley EB	626 392 1	A
48	R31	Resistor, Fixed, Composition: 180K ohms ±10% 1/2W; Allen-Bradley EB	626 184 1	A
49	R35,36	Resistor, Fixed, Composition: 56K ohms ±10%, 1/2W; Allen-Bradley EB	626 563 1	A

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DATE 2 / 8 / 63

UNIT TITLE

DUAL DC AMPLIFIER

MODEL NO.

6.617 Sh.3 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	CR1,6	Diode, Germanium: Clevite CTP462	614 043 0	B
2	CR2,5	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
3	CR3,4	Rectifier, Silicon: Hughes Semiconductor HR10212	614 034 0	B
4	Q1,2	Transistor, Germanium: PNP; Motorola 2N652	686 084 0	B
5	R1,4	Resistor, Fixed, Composition: 6.8K ohms ±10%, 1/2W; Allen-Bradley EB	626 682 1	A
6	R2,3	Resistor, Fixed, Composition: 68K ohms ±10%, 1/2W; Allen-Bradley EB	626 683 1	A

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DATE 2 / 5 / 63

UNIT TITLE

COMMAND RELAY DRIVE

MODEL NO.

11.158 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,3,11,12	Capacitor, Variable, Glass: 1PF to 60PF, 1000V; J.F.D. Electronics Corp. MC626	524 016 0	B
2	C5	Capacitor, Fixed, Ceramic: 5PF ±10%, 1000V; Cornell-Dubilier L10V5	515 204 0	A
3	C7	Capacitor, Variable, Glass: 1PF to 4PF, 1000V J. F. D. Electronics Corp. MC621	524 015 0	B
4	C8	Capacitor, Fixed, Ceramic: 390PF Approximate (Exact Value Determined at Time of Manufacture)	Order by Description	C
5	C9	Capacitor, Fixed, Ceramic: 47PF approximate (Exact Value Determined at Time of Manufacture)	Order by Description	C
6	C10	Capacitor, Fixed, Ceramic: 47PF ±10%, 500V; Erie Resistor Corp. GP1K-47±4.7	515 032 0	A
7	C13	Capacitor, Fixed, Ceramic: 120PF ±10%, 500V; Erie Resistor Corp. GP2K -120 ±12	515 038 0	A
8	CR1,3	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
9	CR2,4,6,9	Diode, Germanium: Clevite CTP462	614 043 0	B
10	CR7,8	Diode, Silicon: Zener; Motorola 1/4M 5.1AZ5	614 144 0	B
11	R1	Resistor, Fixed, Wirewound, Precision: 111,100 ohms ±.05%, ±.005% Stability; Julie Research Labs. H44 Type	B638 822 0	C
12	R2	Resistor; Fixed Wirewound, Precision: 10,000 Ohms ±.05%, ±.005% Stability; Julie Research Lab. H44 Type	B638 821 0	C
13	R3	Resistor, Fixed, Wirewound, Precision: 1,000 ohms ±.05%, ±.005%, Stability; Julie Research Labs. H44 Type	B638 820 0	C
14	R4,5	Resistor, Fixed, Wirewound, Precision: 500,000 ohms ±.05%, ±.005% Stability; Julie Research Labs. H34 Type	B638 826 0	C
15	R6	Resistor, Variable, Wirewound: 1K ohms ±10%, 2W; Atohm Electronics 114-102	642 557 0	B
16	R7	Resistor, Variable, Wirewound: 200 ohms ±10%, 2W; Atohm Electronics 114-201	642 555 0	B

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DATE 2 / 8 / 63

UNIT TITLE

RESISTOR NETWORK

MODEL NO.

12.884 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R8	Resistor, Variable, Wirewound: 20 ohms ±10%, 2W; Atohm Electronics 114-200	642 554 0	B
18	R9	Resistor, Variable, Wirewound: 10K ohms ±10%, 2W; Atohm Electronics 114-103	642 558 0	B
19	R10	Resistor, Variable, Composition: 1 MEG ohm ±20%, .25W; Bourns Laboratories 215P-1-105	642 413 0	B
20	R11	Resistor, Fixed, Composition: 10 MEG ohms ±10%, 1/2W; Allen Bradley EB	626 106 1	A
21	R12-15	Resistor, Fixed, Wirewound, Precision: 25,000 ohms ±.05%, ±.005% Stability; Julie Research Labs. H34 Type	B638 825 0	C
22	R16-19	Resistor, Variable, Wirewound: 250 ohms ±10%, 2W; Atohm Electronics 114-251	642 556 0	B
23	R20	Resistor, Fixed, Composition: 18 MEG ohms ±5%, 1/2W; Allen Bradley EB	626 186 0	A
24	R21,22	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W; Allen Bradley EB	626 123 1	A

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DATE 2 / 8 / 63

UNIT TITLE
RESISTOR NETWORK

MODEL NO.
12.884 Sh. 2 of 2Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C3	Capacitor, Fixed, Ceramic: 82 PF ±10%, 500V; Erie Resistor Corp. GPIK-82±8.2	515 036 0	A
2	CR1,2	Diode, Silicon: Hughes Semiconductor HD5000	614 146 0	B
3	CR3	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
4	R1	Resistor, Variable, Wirewound: 20 ohms ±10%, .25W; Bourns Laboratories 200P-1-200	642 312 0	B
5	R2	Resistor, Fixed, Wirewound, Precision: 5000 ohms ±.05%, ±.005% Stability; Julie Research Labs. H34	B638 824 0	C
6	R3	Resistor, Fixed, Wirewound, Precision: 25,000 ohms ±.05%, ±.005% Stability; Julie Research Labs. H34	B638 825 0	C
7	R4	Resistor, Fixed, Wirewound, Precision: 2,490 ohms ±.05%, ±.005% Stability; Julie Research Labs. H34 Type	B638 823 0	C

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DATE 2 / 6 / 63

UNIT TITLE
AMPLIFIER NETWORK

MODEL NO.
12,889

Sh.1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Electrolytic: 25 UF +20% -15%, 30V; Sprague 130D256C2030F2	516 265 0	A
2	C2	Capacitor, Fixed, Plastic: .15uF ±5%, 150V; Southern Electronics Corp., MMYW-154J15ATF	521 160 0	B
3	C3	Capacitor, Fixed, Electrolytic: 15UF, 15V; Sprague TE-1156	516 259 0	A
4	C4	Capacitor, Fixed, Plastic: 1UF ±10%, 150V Southern Electronics Corp., MMYW-1-10-150 TF	521 161 0	B
5	C5	Capacitor, Fixed, Plastic: 2UF ±10%, 150V Southern Electronics Corp. MMYW-2-10-150 TF	521 061 0	B
6	CR1	Diode, Silicon: Hughes Semiconductor IN459	B614 007 0	B
7	CR2,3	Diode, Germanium: Clevite CTP462	614 043 0	B
8	CR4	Diode, Silicon: Zener; Motorola 1/4M5.1AZ5	614 145 0	B
9	R2	Resistor, Fixed, Compostion: 180 ohms ±10%, 1/2W; Allen-Bradley EB	626 181 1	A
10	R3,8	Resistor, Fixed, Compostion: 560 ohms ±10%, 1/2W; Allen-Bradley EB	626 561 1	A
11	R4	Resistor, Fixed, Wirewound, Precision: 25,000 ohms ±.05%, ±.005% stability; Julie Research Labs. R34 Type	A638 532 0	C
12	R5	Resistor, Fixed, Wirewound, Precision: 5,458 ±.05%, ±.005%, Stability; Julie Research Labs. H-34 Type	B638 837 0	C
13	R6	Resistor, Variable, Wirewound: 200 ohms ±10%, .25W; Bourns Laboratories 200P-1-201	642 315 0	B
14	R7	Resistor, Fixed, Composition: 1K ohms ±10%, 1/2W; Allen-Bradley EB	626 102 1	A
15	R9	Resistor, Fixed, Wirewound, Precision: 12,500 ohms ±.05%, ±.005%, Stability; Julie Research Labs. H-34 Type	B638 838 0	C
16	R10	Resistor, Fixed, Composition: 12K ohms ±10%, 1/2W; Allen Bradley EB	626 123 1	A

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DATE 2 / 25 / 63

UNIT TITLE
AMPLIFIER NETWORK

MODEL NO.
12.890

Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1,3,6,8,9,11	Capacitor, Fixed, Electrolytic: 50 UF, 25V; Sprague TE-1209	516 149 0	A
2	C2,7,10	Capacitor, Fixed, Electrolytic: 10 UF, 12V; Sprague TE-1128	516 150 0	A
3	CR1,2,5,6 8,9	Rectifier, Silicon: Pacific Semiconductors PSC05	614 035 0	B
4	CR3,7,10	Diode, Silicon: Zener, 1N754 Type	614 046 0	B
5	Q1,7,10	Transistor, Germanium: PNP; 2N235A Type	686 034 0	A
6	Q2,3,8,9,11, 12	Transistor, Germanium: PNP; Industro	B686 032 0	B
7	R1,2,13,14, 20,21	Resistor, Fixed, Composition: 4.7K Ohms ±10%, 1/2W; Allen-Bradley EB	626 472 1	A
8	R3,15,22	Resistor, Fixed, Composition: 10K Ohms ±10%, 1/2W; Allen Bradley EB	626 103 1	A
9	R4,16,23	Resistor, Fixed, Composition: 1K Ohms ±10% 1/2W; Allen-Bradley EB	626 102 1	A
10	R5,7,17,19, 24,26	Resistor, Fixed, Composition: 560 Ohms ±10%, 1/2W; Allen-Bradley EB	626 561 1	A
11	R6,18,25	Resistor, Variable, Wirewound: 200 Ohms ±10%, .25W; Bourns 266-1-201	642 327 0	B
12	R29,30,31	Resistor, Fixed, Wirewound: 20 Ohms ±5%, 3W Ward Leonard 3X20	636 265 0	A

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DATE 3 / 11 / 63

UNIT TITLE

POWER SUPPLY REGULATOR

MODEL NO.

43.031-2 Sh.1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	B1	Fan, Muffin Venturi; 110V 60 cps, 13 Watts; Rotron Mfg. Co.	B242 022 1	C
2	C1	Capacitor, Fixed, Electrolytic: 4000 UF, 15V Sprague TVL-1173	516 044 0	A
3	C2	Capacitor, Fixed, Electrolytic (Dual): 200-200 UF +100% -10% 250V; P.R. Mallory FP217.74	516 139 0	A
4	C3-5	Capacitor, Fixed, Electrolytic: 2000 UF, 50V P.R. Mallory WP TS-17123	516 239 0	B
5	C6	Capacitor, Fixed, Paper: .5 UF ±10%, 600V; Sprague BP506	520 074 0	A
6	C7	Capacitor, Fixed, Plastic: .47 UF ±5%, 150V Southern Electronics	521 059 0	C
7	CR1,2	Rectifier, Silicon: Hughes Semi-Conductor HR 10212	614 034 0	B
8	DS1-4	Digital Display Indicator: Industrial Electronic Engineers, Inc. 10984-47	B554 016 0	C
9	DS5	Digital Display Indicator: Industrial Electronic Engineers, Inc. 10K61-47B	B554 022 1	C
10	F1	Fuse, Cartridge, Slow Acting Type: 1 amp, 125V; Littelfuse 313001	570 111 0	A
11	K1	Relay: 430 ohm DC Coil, 4 Form C Contacts; Allied Controls T-154X-158	B618 157 1	C
12				
13	NW1	Resistor Network	C012 879 0	C
14	Q1-4	Transistor, Germanium: PNP, Bendix 2N1136A Type	686 066 0	B
15	R1-S4	Switch, Rotary and Resistor, Variable: 10K ohms	C658 195 0	C
16	R2,3	Resistor, Variable, Composition: 10K ohms ±20%, 1/2W; Allen-Bradley Type G	A642 364 0	A

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DATE 3 · 6 · 63

UNIT TITLE

AUTO RANGE SWITCHING TDVOM

MODEL NO.

26.212-1 Sh. 1 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R5,6	Resistor, Fixed, Wirewound: 20 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 421 0	B
18	R7	Resistor, Fixed, Wirewound: 33 ohms ±5%, 2W; Ward Leonard 2X33	636 425 0	A
19	R8	Resistor, Fixed, Wirewound: 100 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 422 0	B
20	R9	Resistor, Fixed, Wirewound: 82 ohms ±5%, 2W; Ward Leonard 2X82	636 426 0	A
21				
22	R11	Resistor, Fixed, Wirewound: 1.5 ohms ±5%, 10W; Milwaukee Resistor Co.	C636 423 1	B
23	R13	Resistor, Fixed, Composition: 6.8K ohms ±10% 2W; Allen-Bradley HB	628 682 1	A
24	R14	Resistor, Fixed, Composition: 470 ohms ±10% 1/2W; Allen-Bradley EB	626 471 1	A
25	S2	Switch, Toggle: DPDT; Microswitch 6AT3	664 029 0	B
26	S3,8	**Switch, Rotary (Dual): 1 Sect. 11 Pos. Front Index, 1 Sect. 2 Pos. Rear Index; Centralab**	**B658 201 0**	**C**
27	S5,7	Switch, Rotary and Push: Centralab PA-037 and Grayhill Inc. 23-1	C658 196 0	C
28	T1	Transformer, Power: **115V/230V, 50/60CPS** Primary, 2EA 39 VCT 1 EA 36 VCT 1 EA 6.3V and 1 EA 220VCT Secondaries; Sterling ST26280	B684 172 0	C

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DATE 3 / 6 / 63

UNIT TITLE

AUTO RANGE SWITCHING **TDVOM**

MODEL NO.

26.212-1 Sh. 2 of 2 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C1	Capacitor, Fixed, Ceramic: .01UF +60% -40%, 150V; Centralab DDM-103	515 151 0	A
2	CR3-6	Rectifier, Silicon: Hughes Semiconductor HR10212	614 034 0	B
3	K2,5	Relay: 24 Volt, 365 Ohm Coil, 4 Form C Contacts: Potter and Brumfield MH-17D	618 180 0	B
4	K3,4	Relay: 24 Volt, 245 Ohm Coil, 6 Form C Contacts: Potter and Brumfield MH-23D	618 181 0	B
5	R10,12	Resistor, Fixed, Composition: 6.8 Ohms ±10%, 1W; Allen-Bradley GB	627 689 1	A

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DATE 1 /22 /63

UNIT TITLE

INPUT SWITCHING RELAYS

MODEL NO.

11.159 Sh. 1 of 1 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
1	C2	Capacitor, Fixed, Electrolytic: 2 UF +100% 15%, 25V, Sprague TE-1201	516 236 0	A
2	C3,4	Capacitor, Fixed, Ceramic: 3000 PF ±20% 75V; Glenco Min-K-3000-M	515 149 0	B
3	C5	Capacitor, Fixed, Ceramic: 4700PF ±20% 1000V; Cornell-Dublier BYA10D47M	515 008 0	A
4	C6,10	Capacitor, Fixed, Ceramic: 1000PF GMV 600V; Cornell-Dublier BYA6D1	515 005 0	A
5	C7	Capacitor, Fixed, Ceramic: 330 PF ±10%, 500V; Erie Resistor Corp. GP2K-330 ±33	515 044 0	A
6	CR4,5, 8,9,11,12, 14,15	Diode, Germanium: Clevite CTP462	614 043 0	B
7	CR6,10	Diode, Silicon: Continental Device Corp. CD1282	B614 117 0	C
8	CR7,13	Diode, Silicon: Zener; Motorola 1/4M17Z5	614 118 0	B
9	Q1-4	Transistor, Germanium: PNP; Industro	B686 032 0	C
10	R1	Resistor, Variable, Wirewound: 500 ohms ±10% 1/4W; Bournes Laboratories 200P-1-501	642 316 0	B
11	R1p	Resistor, Fixed, Wirewound, Precision: 250 ohms ±2 ohms; Resistance Products; L21X Type	Order by Description	C
12	R2,3	Resistor, Variable, Wirewound: 100 ohms ±10% 1/4W; Bournes Laboritories 200P-1-101	642 314 0	B
13	R2p	Resistor, Fixed, Wirewound, Precision: 300 ohms ±2 ohms; Resistance Products L21X Type	Order by Description	C
14	R3p	Resistor, Fixed, Wirewound, Precision: 200 ohms ± 2 ohms; Resistance Products L21X Type	Order by Description	C
15	R4	Resistor, Variable, Wirewound: 50 ohms ±10% 1/4W; Borns Laboratories 200P-1-500	642 313 0	B
16	R4p	Resistor, Fixed, Wirewound, Precision: 100 ohms ±1 ohm; Resistance Products L21X Type.	Order by Description	C

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DATE 7 / 1 / 62

UNIT TITLE
NETWORK CARD

MODEL NO.
12.687-1

Sh.1 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
17	R5	Resistor, Fixed, Composition: 100K ohms ±10% 1/2W; Allen-Bradley EB	626 104 1	A
18	R6	Resistor, Fixed, Composition: 22K ohms ±10% 1/2W; Allen-Braley EB	626 223 1	A
19	R7,10	Resistor, Fixed, Composition: 3.3K ohms ±10% 1/2W; Allen-Bradley EB	626 332 1	A
20	R8	Resistor, Fixed, Composition: 15K ohms ±10% 1/2W; Allen-Bradley EB	626 153 1	A
21	R9	Resistor, Fixed, Composition: 68K ohms ±10% 1/2W; Allen-Bradley EB	626 683 1	A
22	R11	Resistor, Fixed, Composition: 18K ohms ±10% 1/2W; Allen-Bradley EB	626 183 1	A
23	R12,13,25, 26	Resistor, Fixed, Composition: 10K ohms ±10% 1/2W; Allen-Bradley	626 103 1	A
24	R14	Resistor, Variable, Wirewound: 10 ohms ±10% 2W; Athom Electronics 114-100	642 534 0	B
25	R14p	Resistor, Fixed, Wirewound, Precision: 28 ohms ±1%, 1/4W; Resistance Prod. Co. L-21X Type	Order by Description	C
26	R15	Resistor, Fixed, Wirewound, Precision: 50,000 ohms ±.05%; Julie Research Labs R34 Type	638 046 0	B
27	R16	Resistor, Variable, Wirewound: 20K ohms ±10% 1/4W; Bourns Laboratories 200P-1-203	642 321 0	B
28	R17	Thermister: 10K ohms ±10% at 25°C; General Electric 1D101	646 031 0	B
29	R18	Resistor, Fixed, Composition: 56 ohms ±10% 1/2W; Allen-Bradley EB	626 560 1	A
30	R19, 21	Resistor, Fixed, Wirewound, Precision (Matched Pair) 2EA 10,000 ohms ±.05%	A638 272 0	C
31	R20	Resistor, Variable, Wirewound; 20 ohms ±10% 1/4W; Bourns Laboratories 200P-1-200	642 312 0	B
32	R22,23	Resistor, Fixed, Composition: 12K ohms ±10% 1/2W; Allen-Bradley EB	626 123 1	A
33	R24	Resistor, Fixed, Composition: 56K ohms ±10% 1/2W; Allen-Bradley EB	626 563 1	A

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DATE 7 /6 /62

UNIT TITLE

NETWORK CARD

MODEL NO.

12.687-1 Sh. 2 of 3 Sh.

ITEM	REF. DESIG.	DESCRIPTION	EAI NO.	*CAT.
34	R28	Resistor, Fixed, Wirewound, Precision: 5000 ohms ±.05%, ±.005% Stability; Julie Research Labs WB-375 Type	B638 768 0	C
35	R28p	Resistor, Variable, Wirewound: 50 ohms ±5%, 1W; Daystrom-Pacific 301-60 Type	B642 435 0	C

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DATE 3 / 6 / 63

UNIT TITLE

NETWORK CARD

MODEL NO.

12,687-1 Sh. 3 of 3 Sh.